JUN 1 1 1923

VOL. XII NO. 6

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

JUNE 1923

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

A Stationary Brake Drum and a Brake Shoe

A Spring to Move the Shoe Around the Drum in One Direction

A Strap to Pull the Shoe Back Around the Drum in the Other Direction

THAT is all there is to a Stabilator. No oil or grease is ever necessary, simply because there are no bearings or moving parts to require oil or grease.

The spring is eight feet long and the work at any one point on the spring is too microscopic to be noticeable.

The only possible noise in a Stabilator would be frictional noise, and this possibility has now been wiped out 100% by means of permanent lubricating inserts which extend through the entire thickness of the brake shoe.

The above refinements merely round out the perfection of the Stabilator—a device which, in principle, is the acknowledged standard, as it provides a braking resistance to spring recoil which, regardless of the extent to which the spring has been compressed, is always in proportion to the *force* of the recoil.

Stabilators do the work right and keep on doing it without attention.

JOHN WARREN WATSON COMPANY
Twenty-fourth and Locust Streets
Philadelphia

WATSON STABILATORS

GIVE MOTORISTS THE RIDING QUALITIES THEY WANT

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XII June, 1923 No. 6

Chronicle and Comment

Research Department Announcement

JOHN A. C. WARNER, formerly chief of the aeronautic instruments section of the Bureau of Standards, has been made Assistant Research Manager of the Society. The return of Dr. H. C. Dickinson to the Bureau of Standards after several months' extension of his leave of absence from that institution will not deprive the Research Department of his participation in its work. Arrangements have been made whereby he will be able to give a substantial amount of time to active work with the Research Department in New York City, in furtherance of the cooperative program between the Bureau of Standards and the automotive and the petroleum industries.

The general supervision of the work of the Research Department will not be changed; there will be no interruption of its activities in any particular, and we believe that with the continuance of the present hearty support of the membership the value of this Department will continue to grow at an increasing rate.

A Valuable Service

ENGINEERING publications, trade papers, laboratory reports, technical books and other valuable literature in the several branches of automotive engineering are received currently at the Society headquarters in New York City. This material comes from many sources, both foreign and domestic. It is studied with reasonable care by the members of the staff and the important articles or data are indexed in the reference files of the Research Department. For the benefit of THE JOURNAL readers it has been decided to carry these references currently in a section of THE JOURNAL in the future. The plan was started with the May issue and the members' attention is directed to p. 12 of the advertising section of that issue where many valuable references, abstracts and reviews will be found under the heading "Notes and Reviews". While this column is not represented as completely covering all automotive literature, it will be found to be fairly comprehensive, particularly in calling attention to matter that does not receive general circulation.

Members will be assisted in procuring copies of any of the original material referred to in Notes and Reviews. They are encouraged also to bring valuable articles or reports to the attention of the Research Department for mention in this new department. Notes and Reviews for this month will be found starting on p. 10 of the advertising section.

Division Reports

THE regulations of the Standards Committee provide that all recommendations approved by Divisions of the Standards Committee shall be acted upon at regular or special meetings of the Standards Committee. In the case of the Division reports printed on pp. 565 to 585 inclusive of this issue, the Standards Committee will act upon them during the first day of the Summer Meeting at Spring Lake this month.

Although the reports as approved by the Standards Committee must be confirmed by the Council, at the Society Business Meeting and by the voting members of the Society by letter ballot, the Standards Committee Meeting presents the last practical opportunity for Society members or non-members, who are of the opinion that the recommendations do not meet the requirements of the industry, to submit evidence, in person or in writing, supporting their opinions. In reading the reports in this issue, it should therefore be borne in mind that the recommendations are tentative and may receive extensive revision or may even be referred back to the Divisions submitting them for further study.

Elimination of Waste Effort

THE following statement is quoted from a letter received by the Society in answer to a general inquiry, which had been sent to passenger-car body builders and passenger-car companies constructing bodies, requesting comments on a tentative recommendation on aluminum molding submitted by a Subdivision of the Passenger-Car Body Division.

> It is to be regretted that the automobile industry has not realized long before this time the enormous amount of waste effort caused by the unnecessary lack of standards in so many of the minor parts that enter into the construction of the finished car, and it is with great satisfaction that we note the efforts of the Society toward standardization.
>
> Although the work of the Passenger-Car Body Division on the formulation of body standards is progressing slowly, it is believed that the work is on a sound

basis and the executives of body and passenger-car manufacturers should make it possible for their companies to realize the economic benefits which may be gained through the adoption of the standards in future practice.

The Summer Meeting

THE arrival of the month of June ushers in the popular Summer Meeting of the Society. Spring Lake, N. J., has been chosen as the site of the 1923 meeting. Located on the Atlantic seashore and boasting of two fine resort hotels and unusually complete sports facilities, Spring Lake provides an appropriate setting for a successful assembly of the industry's engineering executives. The technical activities will concentrate on four outstanding topics: four-wheel brakes, large-section air-cushion tires, head-lamp glare, and fuel volatility in relation to crankcase-oil dilution. Instructive demonstrations form an important part of each of the sessions. Railroad fares have been reduced for this occasion and special trains will carry the members direct to Spring Lake without change. Further details are given on p. 617 of this issue of THE JOURNAL and last-minute announcements will reach the members in the Meetings Bulletin about June 5. Reservations of hotel accommodations should be made promptly through the New York City office of the Society. The number of reservations at the time of this issue of THE JOURNAL going to press had reached 631.

Nominating Society Officers

THE nomination of a group of Members to serve as officers of the Society in 1924 will probably be completed and announced at the Summer Meeting by the Nominating Committee of the Society. This committee consists of Members elected by the sections, each Section naming one man and an alternate, and three Members of the Society elected at the business session of the Summer Meeting. There being 11 Sections, the Nominating Committee will have 14 members at Spring Lake. The following have been named for service on the 1923 Committee by the Sections:

Section	*Member*	*Alternate*
Buffalo	E. T. Mathewson	
Cleveland	Ernest Wooler	O. A. Parker
Dayton	Lester Keilholtz	V. G. Apple
Detroit	G. E. Goddard	C. S. Whitney
Indiana	O. C. Berry	
Metropolitan	C. F. Scott	C. T. Myers
Mid-West	T. Milton	R. E. Wilson
Minneapolis	A. W. Scarratt	
New England	V. A. Nielsen	Ira D. Shaw
Pennsylvania	W. M. Newkirk	
Washington	A. W. S. Herrington	

The three members-at-large will be elected at Spring Lake on Tuesday evening, June 19; no two of them can reside in the same Section district.

Intelligence Tests

IN connection with articles on intelligence tests that have appeared in THE JOURNAL, some observations made by E. McCullough as follows are of interest. Gumption, that quality that keeps a man going, is twice as valuable as special training. Some psychologists say that it is impossible to improve the intelligence. The average man believes otherwise. He believes that no psychologist can measure intelligence; that the thing which is measured is only that part of the intellect which reasons. The so-called "intelligence" should be termed mental acumen. There are not many dull persons but there are many who take in ideas slowly. Persistence and ambition count for much. Many quick-thinking men do not always display great common-sense, while many slow-thinking and slow-acting men have a wonderful amount of it. Mental acumen plus education and experience form intelligence.

Society News

DURING the past few months there has been a gradual change in character and scope of certain pages of THE JOURNAL. An effort is being made to report the news of Society meetings and activities in a prompt, complete and interesting manner in the section of THE JOURNAL that follows the formal publication of papers and addresses. This part of THE JOURNAL, which may properly be termed the news section, takes on the character and make-up of the trade paper, and will report current meetings in a style that is easy to read and sets forth the principal engineering thoughts expressed at Society meetings. Use is made of the familiar form of news headline to enable the reader to select readily the matters of greatest interest to him. Illustrations will be used to supplement the printed story and lend more intimacy to the remarks of the speakers. The progress of the Standards Committee Divisions will be recorded in like style as will the actions of the Council and administrative committees.

The outstanding papers read before national and sectional meetings will continue to be published in complete form in the forward part of THE JOURNAL. It is believed that the news reports will appeal particularly to members engaged in non-technical or semi-technical work who may have found it difficult to study the formal technical papers to profit by the engineering information set forth in them. The news matter in this issue starts on p. 610.

Highways

THE State Highway Commission of Iowa has stated that the cost of paving a dirt road can be retired in 9 years by the saving in transportation costs; and that highway taxes, which are only 15 per cent of the total taxes, are responsible for only one-eighth of the total increase in taxes since 1910. Sound policies must be taught in the financing of roads, particularly as respects the relation of bonds to revenues from current fees. The discussion of highway finance is simplified when it can be shown that a given highway reduces the expenditure of a community, or adds to its productivity sufficiently to justify the undertaking. It must be the task of highway research to determine the facts.

The efforts of the highway engineer to build road surfaces have not kept pace with the growth of highway traffic that has arisen so recently and increased so rapidly in the United States. From 1910 to 1921 the investment in rolling-stock has been three times that in roadbeds of highways. No other country has taken up the task of furnishing highways for so large an area, some 3,000,000 square miles. Texas has 262,000, while France has only 212,000 square miles. After many years the Pennsylvania Railroad has completed a roadbed from Chicago to New York City, a distance of 900 miles, over which trains can be operated safely in 20 hours. In the State of Texas a single through-highway will cover an equal distance. Unless the highway program shall be halted by reaction, we face an annual expenditure of nearly $1,000,000,000 for road improvement, provided contractors, men, materials and transportation shall be available.—Dr. W. K. Hatt.

Vol. XII June, 1923 No. 6

An Investigation of Some Heavy-Duty Truck Drive-Axles

By S. VON AMMON[1]

CLEVELAND AUTOMOTIVE TRANSPORTATION MEETING PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

A RECORD of an investigation of heavy-duty truck-axles carried out by the Bureau of Standards at the request of the Motor Transport Division of the Quartermaster Corps, this paper deals in particular with the mechanical efficiency of the axles tested. The investigation included, in addition to several worm-drive Class-B Army-truck axles with different types of bearing, a number of axles usually designated respectively as "internal-gear" and "multiple-reduction" type. Each of these types was represented by axles in successful use in commercial trucks of 5-ton rating.

In analyzing the results of the tests it was found possible to separate the losses into no-load losses and load losses; the total loss being the sum of these two. In general, the no-load losses were primarily controlled by the viscosity and the method of application of the lubricant. They were greater in those axles in which the parts rotating at high speeds were immersed most completely in the lubricant. Where a separate body of lubricant was used in the wheels, the losses were increased still further. In a given axle, these losses also increased with an increase in the viscosity of the lubricant and with the propeller-shaft speeds.

The load losses, expressed as torque, were practically independent of the speed and of the viscosity and the method of application of the lubricant. They increased, however, with an increase of the torque input and at an increasing rate. In the case of the several Class-B worm-type axles tested, the increase in the load losses with an increased torque-input was greater than with any of the gear-type axles.

The use of a lubricant of lower viscosity at low temperatures would improve the mechanical efficiency under the more unfavorable conditions of speed and temperature and seems advisable. Such lubricant should, however, be no less efficient than that used in the tests at the higher temperatures and the heavy pressures resulting from high torque-values. Improvement in the method for circulating the lubricant is suggested as desirable by the results; the high no-load losses of some of these axles show the present method of circulation to be very inefficient. The characteristic difference between the worm-drive and gear-drive types is demonstrated by the greater load losses of the former type.

AN appreciation of the importance of securing more complete information than was available at the time, led the motor transport division of the Quartermaster Corps to request the Bureau of Standards in 1920 to undertake an investigation of the several types of rear axle suitable for heavy-duty trucks. This paper deals with some of the results of this investigation, having particular reference to the mechanical efficiency of the axles tested.

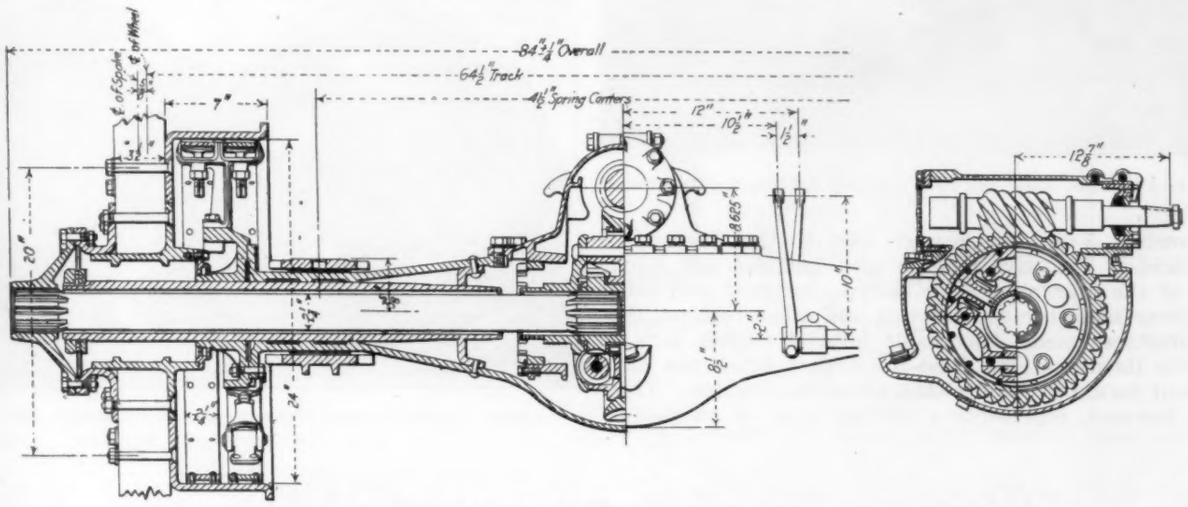


FIG. 1—SECTIONAL VIEW OF THE CLASS B ARMY TRUCK-AXLE EQUIPPED WITH TAPERED ROLLER BEARINGS THROUGHOUT

The interest of the Motor Transport Division was centered largely upon the Class-B 3½ to 5-ton truck and, as a need for replacement axles for this truck was expected, those features and dimensions essential for this use were specified in an invitation issued to axle manufacturers to submit suitable axles. Of these features, the following are of interest here: (*a*) maximum torque-input 17,000 lb-in., (*b*) weight on spring-pads 12,000 lb., (*c*) minimum ground-clearance with 40-in. tires 11½ in., (*d*) maximum reduction-ratio 10.25, (*e*) minimum reduction-ratio 8.90, and (*f*) a non-locking differential. The maximum input-torque was based on 95 per cent of the maximum torque of the standard Class-B-truck engine between 400 to 1200 r.p.m., 3000 lb-in., reaching the axle through the 5.93 to 1 low-gear ratio of the standard Class-B transmission.

In response to the invitation, a number of sample axles

[1] Mechanical engineer, Bureau of Standards, City of Washington.

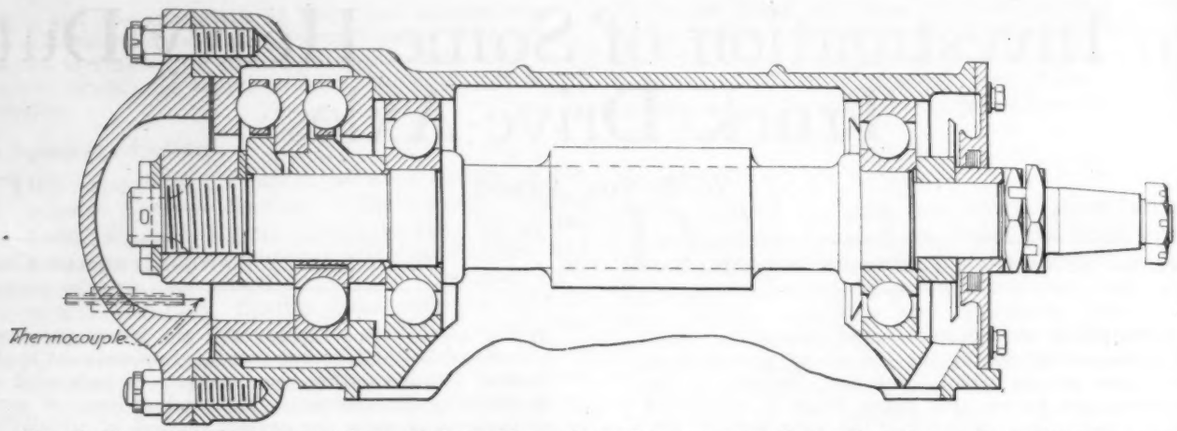


FIG. 2—SECTIONAL VIEW OF THE CLASS B ARMY TRUCK-AXLE EQUIPPED WITH SINGLE-ROW RADIAL BALL BEARINGS AND SHOWING THE LOCATION OF THE THERMOCOUPLE USED TO MEASURE THE LUBRICANT TEMPERATURES

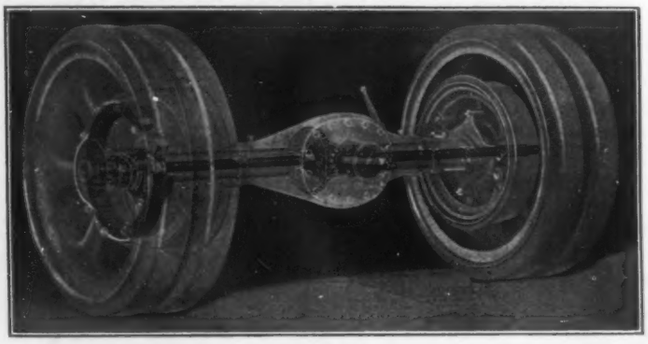


FIG. 3—PHANTOM VIEW OF THE THREE-STAGE DOUBLE-REDUCTION TYPE AXLE

of nominal 5-ton rating were sent to the Bureau of Standards. The investigation also included one 5-ton axle of the multiple-gear-drive type designed and used for lower input-torque; for this and other reasons, the manufacturer made it available for test neither with a view to its use in the Class-B standard truck nor any claim of its ability to meet the above specification. This axle, however, represents a distinct type in successful use, and the test results were therefore expected to be of general interest. The Motor Transport Division furnished a standard Class-B axle, and the necessary worm and differential assemblies for testing this axle with different types of bearing. The Bureau thus had available

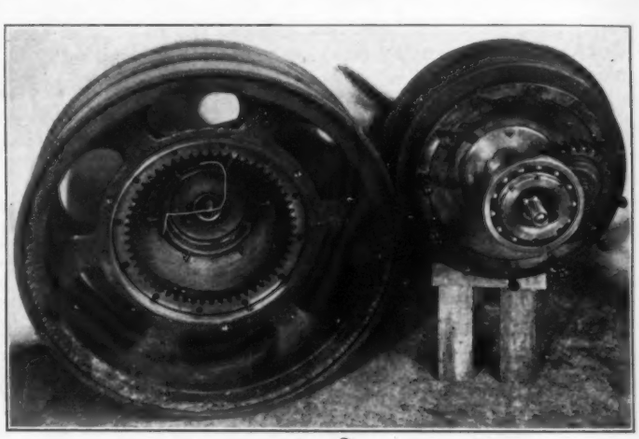


FIG. 4—VIEW OF THE THREE-STAGE DOUBLE-REDUCTION

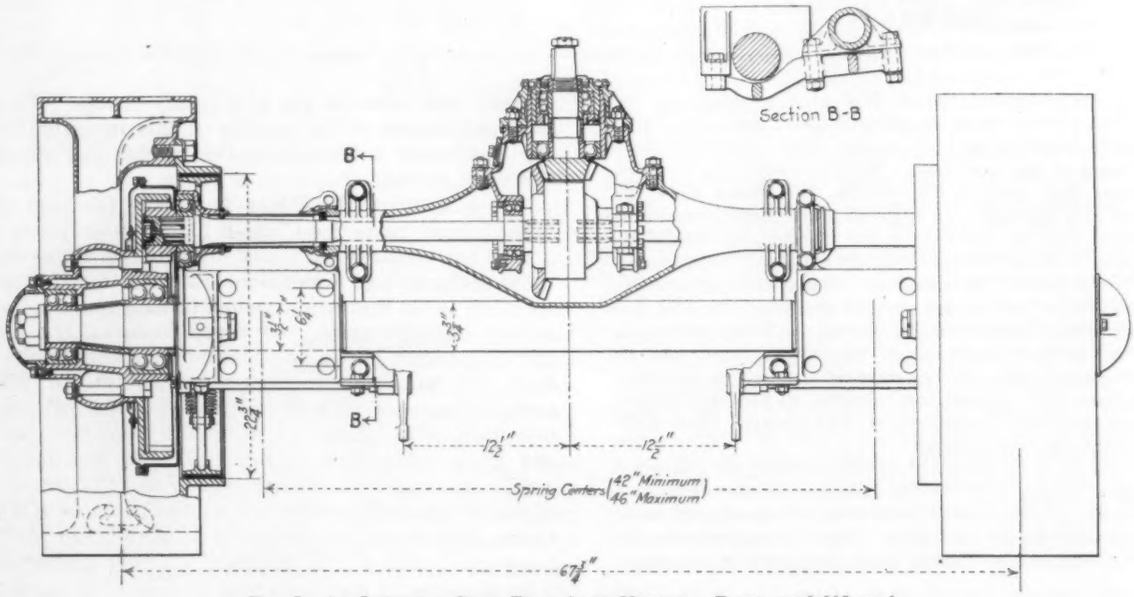


FIG. 5—AN INTERNAL-GEAR TYPE AXLE HAVING A RATIO OF 9.605 TO 1

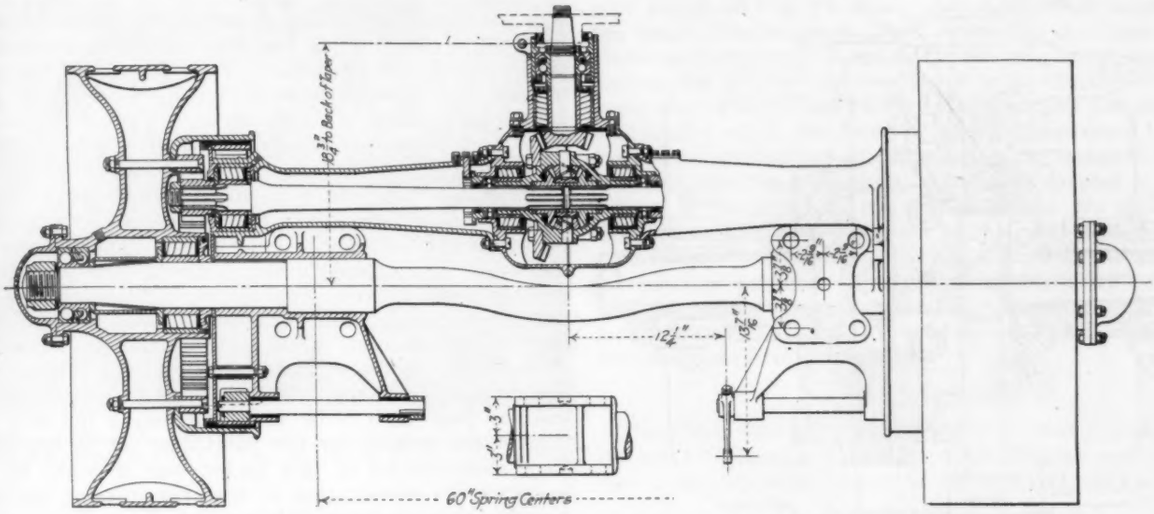


FIG. 6—ANOTHER INTERNAL-GEAR TYPE AXLE HAVING A RATIO OF 12.56 TO 1

for this investigation the following axles of a rated capacity of 5 tons. The same housing, wheel and wheel bearings were used in Axles *A*, *B* and *C*.

Axle A—Class-B Army truck-axle with tapered-roller bearings throughout; ratio 9.5 to 1; shown in Fig. 1.

Axle B—Class-B Army truck-axle with single-row radial ball-bearings and thrust washers for the worm and tapered-roller bearings for the differential; ratio 9.5 to 1; shown in Figs. 1 and 2.

Axle C—Class-B Army truck-axle with three single-row ball-bearings for the worm, one of these taking the thrust load only and the others the radial load only, and tapered-roller bearings for the differential; ratio 9.5 to 1; shown in Figs. 1 and 2.

Axle D—Three-stage double-reduction type; two stages in the wheels; ratio 11 2/3 to 1; shown in Figs. 3 and 4.

Axle E—The same axle as Axle D, but equipped with a bevel pinion and gear for a ratio of 13 1/3 to 1; shown in Figs. 3 and 4.

Axle F—An "internal-gear" type axle; ratio 9.605 to 1; shown in Fig. 5.

Axle G—An "internal-gear" type axle of another make; ratio 12.56 to 1; shown in Fig. 6.

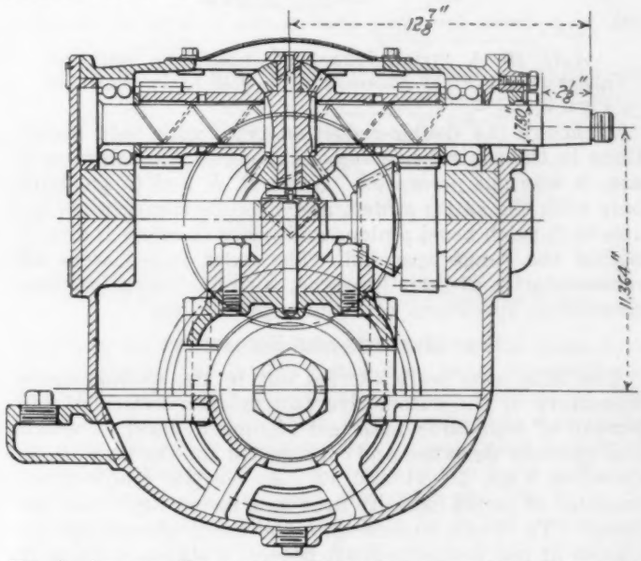


FIG. 8—ANOTHER VIEW OF THE TRIPLE-REDUCTION AXLE SHOWN IN FIG. 7

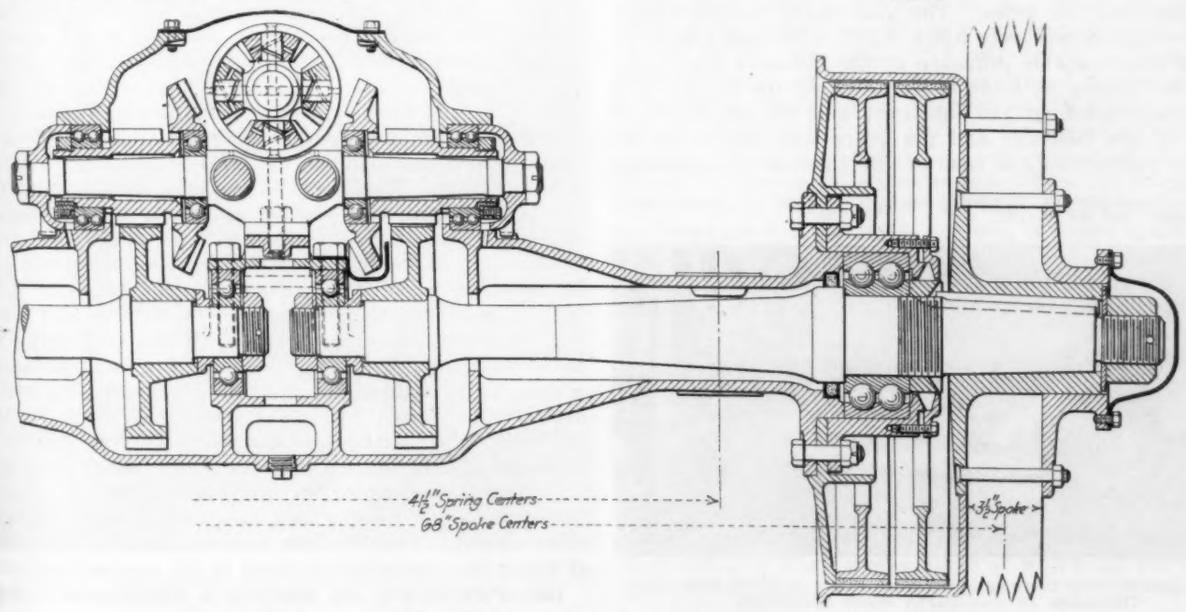


FIG. 7—VIEW OF THE TRIPLE-REDUCTION AXLE WITH ALL GEARS IN A CENTRAL HOUSING

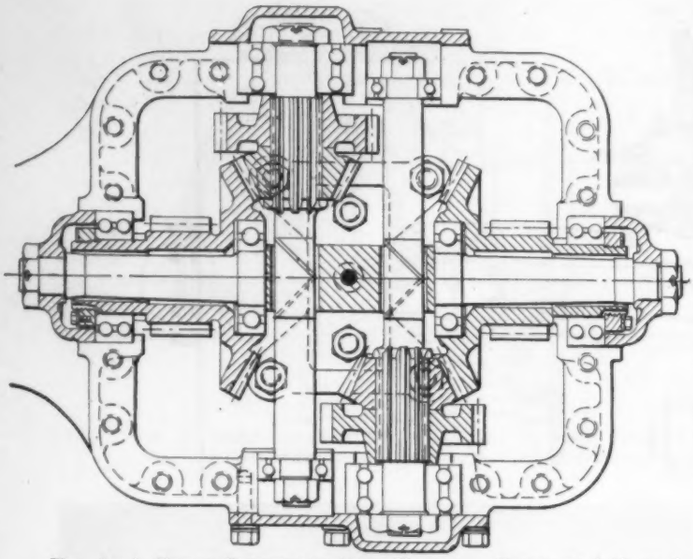


FIG. 9—A TRIPLE-REDUCTION AXLE HAVING A RATIO OF 9.43 TO 1

Axle H—A "triple-reduction" type axle with all gears in a central housing; ratio 9.43 to 1; shown in Figs. 8 and 9.

Although the double-reduction type, with both reductions in the central housing, is in successful commercial use, it was not presented. Axles *D*, *E* and *G* are built only with the ratios stated, and manufacturers were unable to furnish bevel pinions and gears to bring the ratio within the range specified. The axles tested were all representative of their type and, with one exception, representative specimens of regular production.

TEST METHODS AND EQUIPMENT

The axle tests were carried out in the dynamometer laboratory of the automotive powerplants section of the Bureau of Standards with test equipment most of which was specially designed and constructed for the purpose as shown in Figs. 10, 11 and 12. An electric cradle-dynamometer of ample capacity used as a motor furnished the power. To obtain satisfactory and more economical operation at low propeller-shaft speeds, a standard Class-B Army-truck transmission was used between the dynamometer and the axles. The gear-ratios in this transmission are respectively 5.934, 3.237, 1.766 and 1 to 1.

The objectionable influence of the losses in the transmission varying with the speed, the load, the amount and the temperature of the lubricant and the condition of wear of the bearings and the gears was eliminated by rigidly connecting the case of the Class-B transmission by stout braces to the field frame of the cradle dynamometer. A rigid coupling connected the transmission and the dynamometer shafts and the outer end of the transmission case was, because of the large overhang, given additional support in a ball bearing mounted on the floor-plate. A beam secured to the transmission case, as shown in Fig. 11, served for roughly balancing the case. The torque-arm of the dynamometer field-frame thus indicated the axle input-torque, regardless of the losses in the transmission. The balance of the dynamometer system was, however, measurably influenced by the quantity and the temperature of the oil in the transmission and the distribution of this oil as governed by the speed and the gear-ratios used. This could be and was taken care of by running the dynamometer and the transmission disconnected from the axle, before each test, at the speed and the gear-ratio to be used, and noting the zero position of the system for the particular set of conditions. Very close control of this factor was obtained by first bringing the temperature of the transmission oil to the operating temperature and again checking the zero position at the conclusion of each day or after each run with a given speed or gear-ratio.

The transmission main-shaft and the propeller-shaft of the test axle were connected by two flexible couplings joined by a very short shaft splined at both ends; ample flexibility and a means of readily disconnecting the axle resulted. The test axle was mounted on two steel I-beams secured on and overhanging the floor-plate and spaced so that the axles were supported under the spring-pads and secured by heavy bolts as shown in the illustrations. These I-beams extended past the dynamometer and carried at their far ends the weighing gear taking the reaction of the brake-arms. Prony brakes, substantially constructed of structural steel, were used to absorb the power. A uniform surface with the various types of wheel was obtained by mounting on them standard tire-rims as used with the 40 x 6-in. solid tires and, after securing these by pins and welding, machining them to a smooth surface. Each prony-brake was equipped with an upper and a lower pair of flexible steel brake-bands lined with standard brake-lining 5 in. wide. The tension on each brake was adjusted by one heavy bolt, and means were provided for adjusting and equalizing the loads on the different bands.

Some difficulty was experienced at first with the lubrication of these brakes; after several trials, however, graphite grease was found very satisfactory, provided the temperature of the brakes was kept within the limits shown by experience. Even then the small size of the brakes for the horsepower absorbed and the operating conditions required much skill for satisfactory continuous operation. The length of the brake-arms, more than 13 ft., combined with the design of the brakes, reduced any error that may have resulted from slight changes in the location of the brakes on the wheels during the tests. To keep the speed of the two wheels constant, the differentials were locked by filling them with a soft metal. Fig. 12 shows the cross-beams with the knife-edge supports by which the torque of the two brake-beams is added. To facilitate the power measurements, the method first proposed by C. M. Allen and F. W. Roys in their paper entitled Efficiency of Gear Drives,[2] was used. The principle of this method consists of the use of a differential beam for balancing the input-torque against the output-torque. The losses are balanced by an adjustable rider-weight, from the size and necessary displacement of which the transmission losses in the axle are computed.

Referring to Fig. 13, which is a diagrammatic sketch

[2] See TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, vol. 40, p. 101.

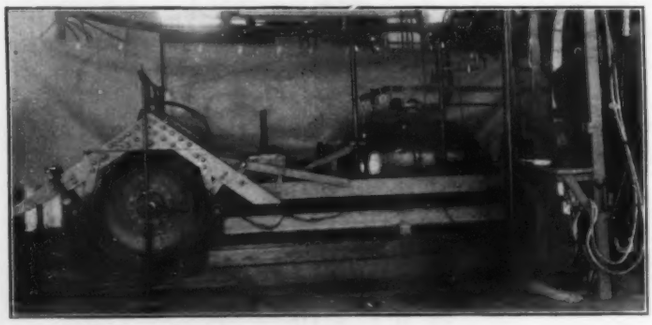


FIG. 10—SIDE VIEW OF THE APPARATUS WITH WHICH THE TESTS DESCRIBED IN THE PAPER WERE CONDUCTED

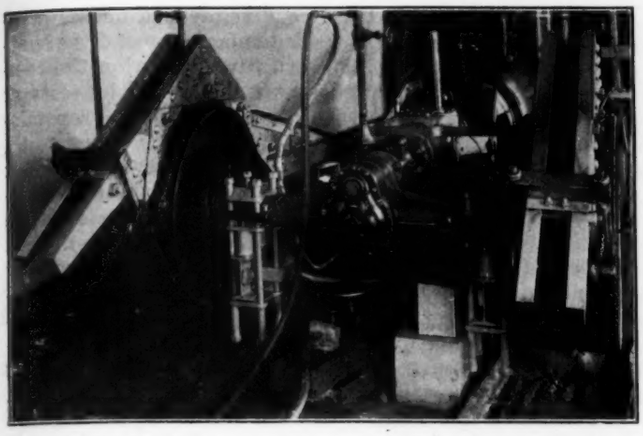


FIG. 11—END VIEW OF THE TEST APPARATUS SHOWING THE BEAM THAT WAS SECURED TO THE TRANSMISSION CASE TO ACT AS A ROUGH BALANCE

of the test equipment, the main knife-edge on the differential beam was carried in a separate block and its position could be altered readily to change the ratio of the two beam-ends as required by the varying reduction-ratios of the several axles. The differential beam was supported by the weigh-beam and, from the net indication of this, the input was calculated. Counterweights were provided at several points, and two simple oil dash-pots to dampen oscillations of the differential beam and the upper weigh-beam were located as shown. The heat generated at the brakes was absorbed by water fed into the hollow of the wheel rims, as shown in Fig. 10, a number of holes being provided for escape of the steam. A sprinkler over each wheel, fed by the overhead water-pipe shown in Fig. 11, served for the further control of the brake temperature. Two additional sprinklers, one above and one under the central housing, were used for cooling the sump and the bearings as required. The sump temperature was raised by a plumber's pot and several blow-torches, the flame of which was covered to prevent local overheating of the sump. The temperature of the lubricant was observed by thermocouples suitably located in the axle and the transmission. No particular difficulties have been met with in the control of the temperatures. The use of two brakes, as well as the utilizing of existing material and finally the flexibility required for testing the various types of axle, resulted in a rather large number of parts. The whole set-up, however, was well made and functioned well.

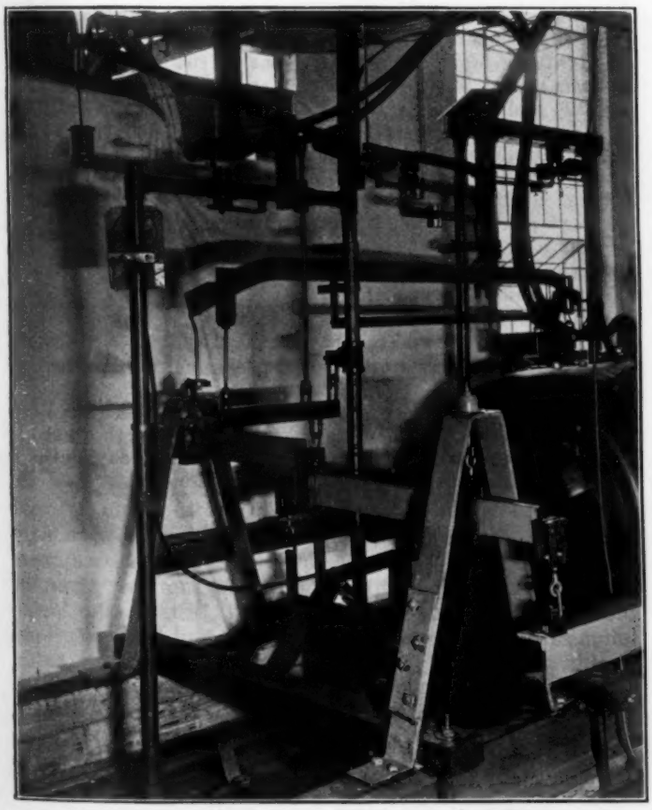


FIG. 12—THE CROSS-BEAMS WITH THE KNIFE-EDGE SUPPORTS BY WHICH THE TORQUE OF THE TWO BRAKE-BEAMS IS ADDED

TEST PROCEDURE

Each axle was given an initial inspection to insure the proper adjustment of the gears and, where possible, of the bearings and proper condition in general. The

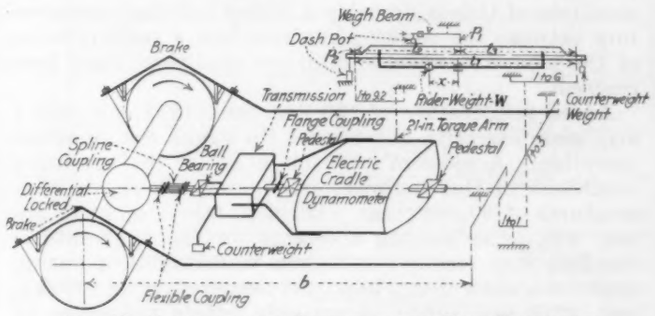


FIG. 13—DIAGRAMMATIC SKETCH OF THE TEST EQUIPMENT

standard brake-drum equipment was left on all axles during the tests; the brakes themselves were, however, removed to avoid any possibility of their rubbing on the drums. All thermocouples were projected reasonably far into the axle housing to assure their being immersed in the circulating oil. Each axle was run for a sufficient time to bed-in the bearings, the gears and the worm, to reduce as far as possible any changes in the mechanical fits during the tests. In these preliminary runs, the axles were run first with gradually increasing loads and then with loads up to about 50 hp. at a speed corresponding to about 8.5 m.p.h., and with oil temperatures ranging up to 100 deg. cent. (212 deg. fahr.). These preliminary runs aggregated several days and gave an opportunity to observe such changes in the losses as usually occurred during this period; the losses usually decreased somewhat at first. The best load conditions and period for running-in are somewhat difficult to determine. While a more severe load or a longer period might have improved some of the axles slightly, it might again have unfavorably affected some of the test results.

The efficiency tests were carried out at speeds corresponding as nearly as convenient to road speeds of 15.0, 12.5, 8.5, 4.5 and 2.5 m.p.h., based on 40-in. tires. To ascertain the influence of the viscosity of the lubricant on the losses, the efficiency tests were made at several oil-temperatures. With the first axle, these were respectively 40 and 80 deg. cent. (104 and 176 deg. fahr.). It was found, however, advisable and possible to extend this range and all other axles were tested at 40, 70 and 100 deg. cent. (104, 158 and 212 deg. fahr.) temperatures of the lubricant. The lowest of these figures, while considerably above the temperature at which the axles must operate at times, was very close to the minimum oil-

temperature that could be maintained with the cooling arrangements available. Many data could be gathered, however, at temperatures lower than 40 deg. cent. (104 deg. fahr.); for instance, during no-load tests and with light and medium loads at the beginning of a day's run. It thus became possible, from such data and by extrapolation, to secure with at least a very fair approximation the performance at the additional temperature of 20 deg. cent. (68 deg. fahr.). Even this by no means covers the conditions frequently met in winter operation. Two factors must, however, be kept in mind; first, that the viscosity of the lubricant used in the tests is very high at low temperatures and that it may therefore be advisable in such a case to use a lubricant of lower viscosity and, second, that in operation at low temperatures the losses will increase the temperature somewhat rapidly.

Reference is made here to a feature frequently noticed; it is that during the first period of a day's run when the oil temperature was low, the losses gradually decreased from a value higher than that corresponding to the same temperature when equilibrium was reached. The explanation of this is probably a higher lubricant-temperature between the working surfaces and a redistribution of the lubricant when equilibrium conditions have been reached.

An oil temperature of 100 deg. cent. (212 deg. fahr.) may seem excessive and beyond the range met in actual operation. A moment's consideration of the operating conditions in the Southwestern States, where air temperatures of 50 deg. cent. (122 deg. fahr.) or more are met, will, after making allowance for the temperature-rise that may readily result from unfavorable operating conditions, show that a lubricant temperature of 100 deg. cent. (212 deg. fahr.) is not only within the range of possibility, but may even be exceeded. The temperature-rise of the lubricant will, of course, depend on the magnitude of the losses, the outside temperature and the heat-dissipating capacity of the structure. Data on the temperature-rise at constant load were obtained by tests at high and at low speeds with a constant power transmission of about 50 hp.

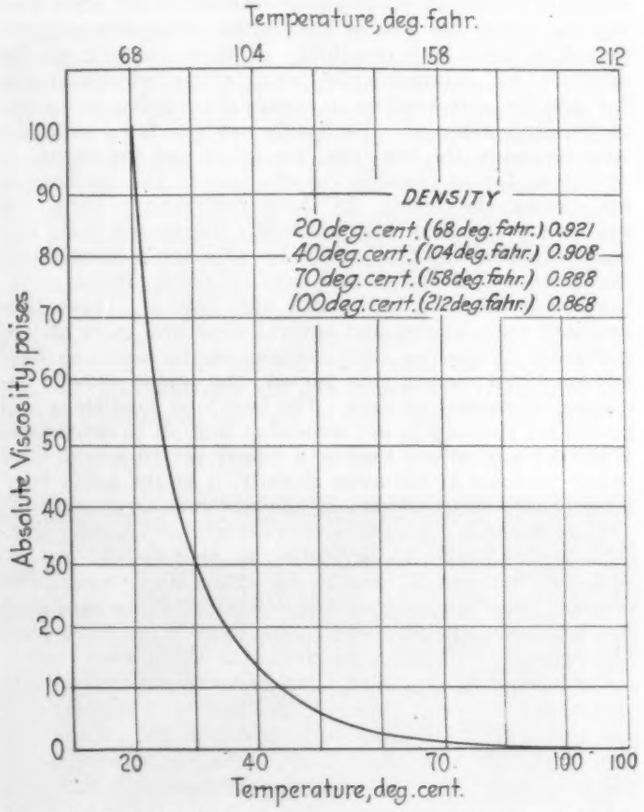


FIG. 14—CURVE SHOWING THE RELATION BETWEEN THE TEMPERATURE AND THE VISCOSITY OF THE TRANSMISSION LUBRICANT USED

In view of possible changes in the axle condition, it was found advisable to add tests to check the losses observed during the main tests; this was done for one lubricant-temperature at high and at low speed, as will be seen from the test program. Each axle was finally submitted to a low-speed test with high torque, at approximately 2.5 m.p.h., and this was designated as "endurance run" and continued in periods of 5 hr. daily until breakdown occurred or was clearly imminent. This run would perhaps be called more properly a "durability" run. It permits a fair estimate of the durability as regards both the mechanical wear and the efficiency of power transmission, these being related to each other. Owing to the differences in the ratios of the various axles, to the fact that the conditions of this test differ so much from what is met in actual service and for other reasons, the periods elapsing before breakdown occurred should not be taken as a direct measure of their relative endurance or capacity. They promised, however, to be of assistance in estimating to some extent the durability and to yield in addition data of value to the designer, not only in comparing the various axles with each other but in demonstrating the relative strength or durability of the various component parts of a given axle, particularly under severe service conditions. The information secured might thus point the way to improvement of the particular axle as a whole, by disclosing any weak links.

TEST PROGRAM

(1) Preliminary power-runs at 8.5 m.p.h. and at temperatures up to 100 deg. cent. (212 deg. fahr.).

(2) Efficiency tests; (*a*) at 8.5 m.p.h. and at temperatures of 40 and 70 deg. cent. (104 and 158 deg. fahr.); (*b*) at 12.5 m.p.h. and at 40 and 70 deg. cent. (104 and 158 deg. fahr.); (*c*) at 15.0 m.p.h. and at 40, 70 and 100 deg. cent. (104, 158 and 212 deg. fahr.); (*d*) at 4.5 m.p.h. and at 40 and 70 deg. cent. (104 and 158 deg. fahr.); (*e*) at 2.5 m.p.h. and at 40, 70 and 100 deg. cent. (104, 158 and 212 deg. fahr.); and (*f*) a short run at 1.7 m.p.h. and at 70 deg. cent. (158 deg. fahr.).

(3) A temperature-rise run at 15 m.p.h. with a constant load of about 50 hp.

(4) A check-run at 70 deg. cent. (158 deg. fahr.) and speeds of (*a*) 15 m.p.h. and (*b*) 2.5 m.p.h.

(5) No-load tests at several speeds and oil-temperatures.

(6) An "endurance" run at 2.5 m.p.h. with constant load of about 50 hp. with an observation of the temperature-rise in periods of about 5 hr. each day until breakdown occurred or was clearly imminent.

All speeds given in this program are in round figures; the actual speeds as shown in the records of each axle vary slightly with each axle-ratio. Various reasons causing departures from this general program are given in the Appendix. For any given speed, tests at the lower temperatures were usually made first, and the exceptions to this are shown. In all tests except the no-load tests, the minimum load was governed by and kept slightly in excess of that resulting from the weight of the brakes. In efficiency tests at a given speed and oil-temperature, readings were taken at from five to seven different loads ranging from this minimum to the maximum applied and were repeated at the same loads while descending.

The procedure was to set the weigh-beam, from which

the differential beam is suspended, to the figure representing the desired load; when, after correcting the brakes and the speed as required, the adjustment of the rider weight on the differential beam indicated a condition of equilibrium, the first reading was taken. After a 3-min. additional application of the same load, the second observation was made and the brakes were adjusted for the next load. During most of the tests, the intervals between the second reading at one load and the first reading at the next load, was 2 min. The maximum load was applied longer, so that at least three readings covering a period of 5 min. were obtained. The no-load tests were made during the latter part of the series to assure the axles being well run-in at the time. Test temperatures were controlled within a few degrees of the nominal figure. In some cases at low test-speeds, the indications of the thermocouples showed a slight lag.

LUBRICANT

Government-specification transmission-lubricant[3] was used in all of the axles tested and, to keep this strictly uniform throughout, the Motor Transport Division furnished the Bureau 1 bbl. of this material. The relation of the temperature to the viscosity of a sample of this oil is shown in Fig. 14. In view of the high viscosity at temperatures below 40 deg. cent. (104 deg. fahr.) and the difficulty of obtaining these with accuracy, this part of the curve must be taken as being approximate only.

[3] See Bureau of Mines Technical Paper No. 323, p. 25.

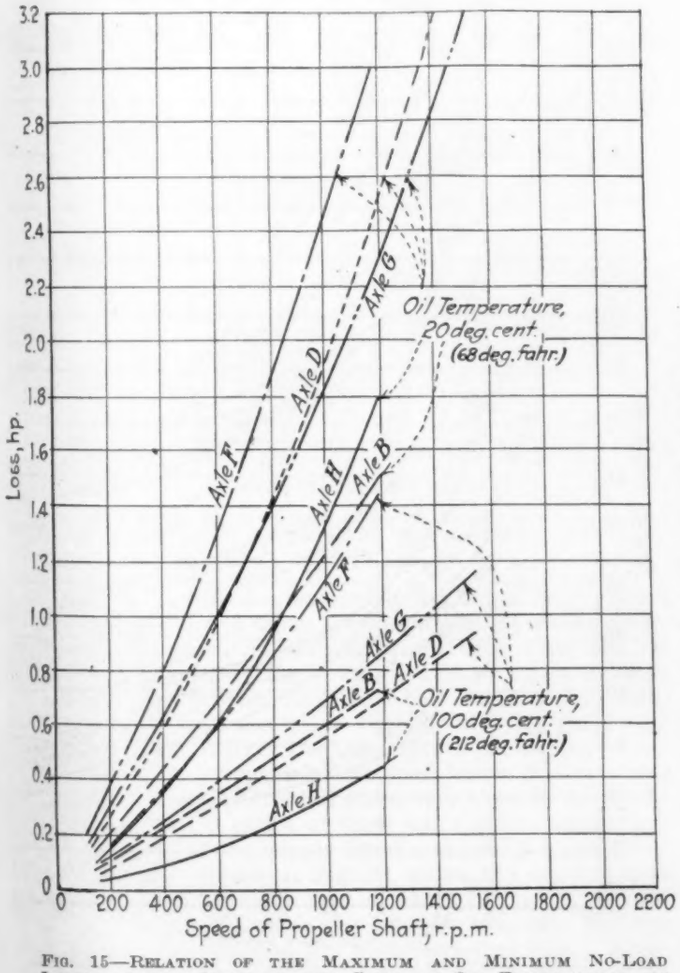


FIG. 15—RELATION OF THE MAXIMUM AND MINIMUM NO-LOAD LOSSES OF THE AXLES TO THE SPEED AT OIL TEMPERATURES OF 20 AND 100 DEG. CENT. (68 AND 212 DEG. FAHR.)

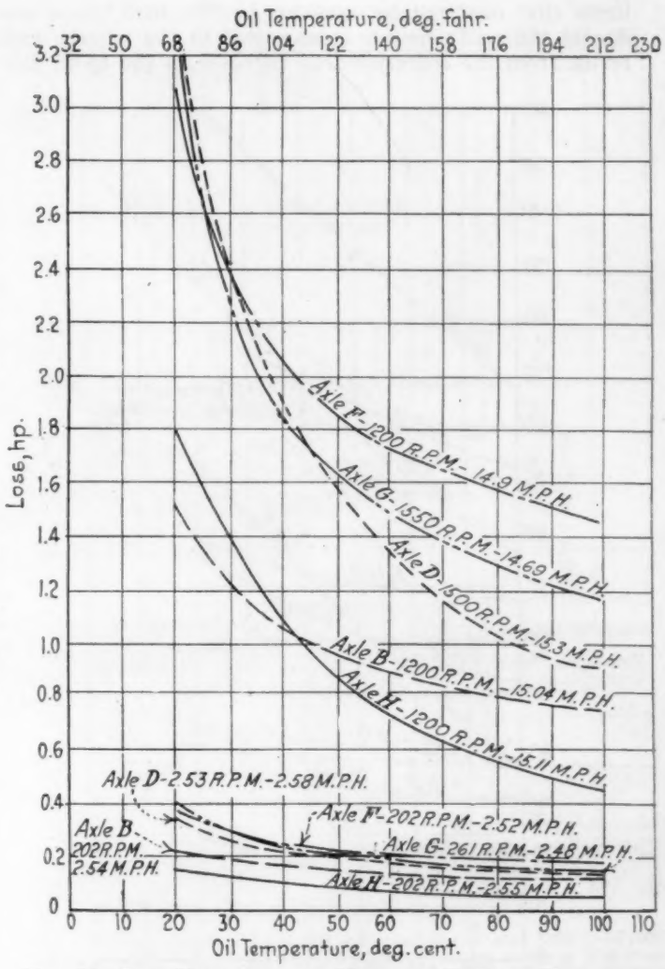

Oil Temperature, deg. fahr.
Loss, hp.
Oil Temperature, deg. cent.
Axle F-1200 R.P.M.-14.9 M.P.H.
Axle G-1550 R.P.M.-14.69 M.P.H.
Axle D-1500 R.P.M.-15.3 M.P.H.
Axle B-1200 R.P.M.-15.04 M.P.H.
Axle H-1200 R.P.M.-15.11 M.P.H.
Axle D-253 R.P.M.-2.58 M.P.H.
Axle F-202 R.P.M.-2.52 M.P.H.
Axle B 202 R.P.M. 2.54 M.P.H.
Axle G-261 R.P.M.-2.48 M.P.H.
Axle H-202 R.P.M.-2.55 M.P.H.

FIG. 16—THE MAXIMUM AND MINIMUM NO-LOAD HORSEPOWER LOSSES PLOTTED AGAINST THE OIL TEMPERATURE AT THE HIGHEST AND THE LOWEST SPEEDS

The oil level in each axle was checked daily, and lubricant was added when necessary. As all tests were made with identical lubricant, the temperature of the latter is referred to throughout; it is of course understood that the corresponding viscosity of the lubricant and not the temperature governs the variation in the results, except as changes in temperature may affect fits and clearances.

RESULTS

The test results have been analyzed to show the respective influence of power, torque, speed, temperature of the lubricant and no-load losses. The consistency of the results is better than was anticipated in view of the many factors affecting the behavior of an axle as a whole. The limited scope of this paper does not permit the presentation of all the data obtained with the axles tested. The data presented have, however, been selected with a view to demonstrating as clearly as possible the characteristic features of the types as shown by Axles *B*, *D*, *F*, *G* and *H*. Summaries of the results obtained in the tests of these five axles are plotted in Figs. 15 to 34.

In studying these results, it is well to consider the losses as made up of no-load losses and "load"-losses. The no-load losses consist of the power expended for the necessary circulating and unnecessary churning of the lubricant, the friction in the bearings and between the gear teeth when not transmitting useful load, the windage of the wheels and the brake-drums and a few smaller

items that need not be considered. The load losses are due to the useful power transmitted to the wheels, and result from the corresponding increase in the tooth and

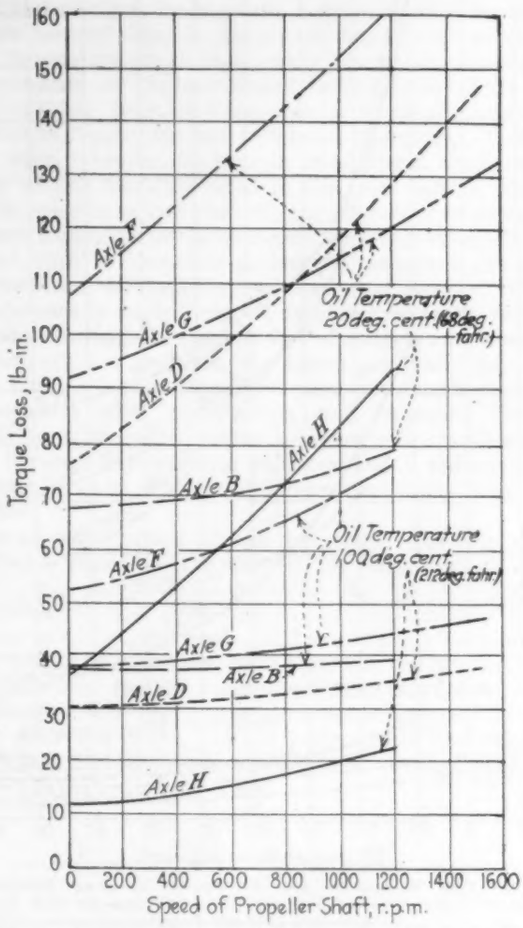


FIG. 17—RELATION BETWEEN THE MAXIMUM AND THE MINIMUM NO-LOAD LOSSES EXPRESSED AS TORQUE AND THE SPEED AT OIL TEMPERATURES OF 20 AND 100 DEG. CENT. (68 AND 212 DEG. FAHR.)

the bearing friction. The additional wheel-bearing losses resulting in road service under a truck and the increase in other bearing and gear losses that may result in such service could not be taken into account in this investigation. Such additions may, however, under unfavorable conditions become more marked with one or another axle.

The no-load losses are plotted in Figs. 15 and 16, and increase materially with increasing viscosity and speed. If, as plotted in Figs. 17 and 18, these losses are expressed as torque, we see that the increase is largely the result of the method of circulating the lubricant. At the high temperature, the torque loss increases but slightly with an increase in speed; on the other hand, a decreasing temperature results in an increase in these no-load losses in conformity with the rise in the viscosity.

Comparing the no-load losses in the different axles, for any speed or temperature at which the oil losses are of any moment, it is found that Axles *B* and *H* show lower values than Axles *D*, *F* and *G*. In Axle *B* the relatively slowly revolving worm-gear and differential and in Axle *H* the final spur-gears on the axle shafts are the only parts immersed in the sump pool in the central housing. This clearly accounts for the lower oil-losses compared with the other axles in which the bevel rings and the differentials rotate at much higher speeds, and the circulation of the lubricant in the wheels causes additional losses. The oil in the wheel would, at least at the higher speeds, tend to rotate with the wheel in a ring at the circumference of the internal-gear chamber. The end of the jackshaft with its pinion projects into this ring of oil of a high viscosity at low temperatures and prevents the orderly progress of the lubricant; the power loss thus occasioned may be smaller with grease if a part of the lubricant adheres to the wall of the chamber away from the pinion, as it may do, particularly at low temperatures. Additional obstructions in the wheel chamber as found in Axle *D* in the intermediate pinion and its supports may add to the losses. That the loss caused by the circulation of the lubricant in the wheel is considerable is clearly shown in the Appendix. The distribution of the lubricant in the central housing, as influenced by constructional features and speed and other smaller factors that need not be gone into here, may have an influence on the losses to be ascribed to the lubricant.

To obtain some data on the no-load losses, runs were made with Axle *H* with several oil-levels. The regular tests of this axle had been made with 3 gal. in the sump, this unusual amount being required because of the large volume of the housing. Fig. 19 shows the no-load losses as observed with 3 gal. of oil at four temperatures over the range of test speeds, as well as the losses at 20 deg. cent. (68 deg. fahr.) with varying amounts of oil. The dotted curve shows that the no-load losses without lubricant in the central housing were constantly higher than with 3 gal. of oil at 70 deg. cent. (158 deg. fahr.)

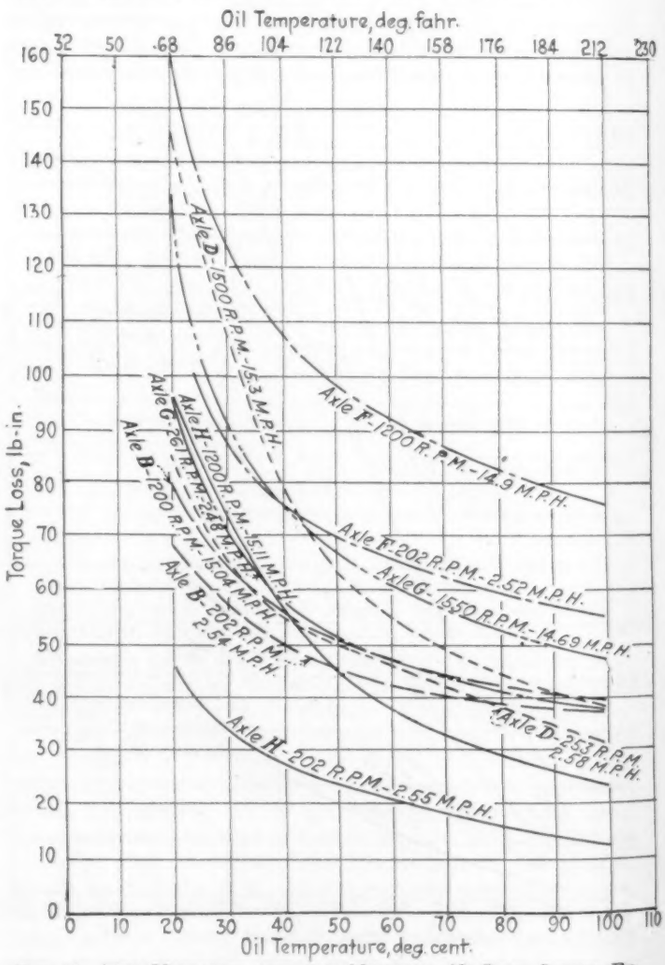


FIG. 18—THE MAXIMUM AND THE MINIMUM NO-LOAD LOSSES EXPRESSED AS TORQUE PLOTTED AGAINST THE OIL TEMPERATURES AT THE HIGHEST AND LOWEST SPEEDS

A study of the load losses expressed as power shows that these increase with the power input and at an increasing rate. There is a fair similarity in the axles of the gear type, but the worm type shows a materially greater increase in these losses with an increasing input than any of the gear-type axles. The viscosity of the oil, however, has no influence on the load losses. These features can be seen readily in Fig. 20. Two apparent exceptions relating in Fig. 20 to Axle *B* are not fully understood. The observed values are slightly lower for 70 deg. cent. (158 deg. fahr.) than for either 40 or 100 deg. cent. (104 or 212 deg. fahr.). Further reference to this is made in the Appendix. The load losses in Fig. 20 also show an increased rate of growth with an increasing load and for a given power input with a decreasing speed.

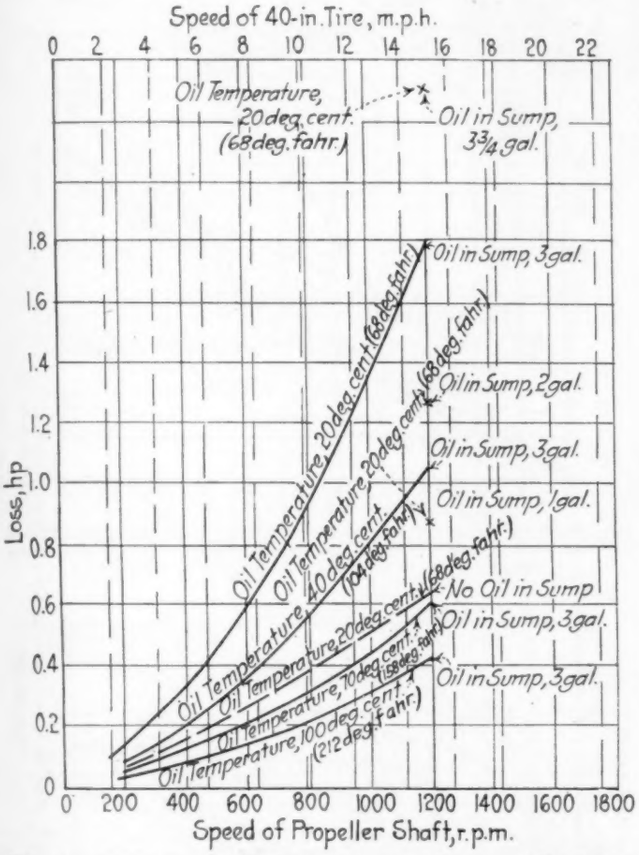

Speed of 40-in. Tire, m.p.h.
Oil Temperature, 20 deg. cent. (68 deg. fahr.)
Oil in Sump, 3¾ gal.
Oil in Sump, 3 gal.
Oil in Sump, 2 gal.
Oil in Sump, 1 gal.
No Oil in Sump
Loss, hp
Speed of Propeller Shaft, r.p.m.

FIG. 19—CURVES OF THE NO-LOAD LOSSES AT DIFFERENT PROPELLER SHAFT SPEEDS AND FOUR DIFFERENT TEMPERATURES OF THE LUBRICANT

If the load losses expressed as torque are plotted against the torque input, we obtain Fig. 21 which shows clearly the similarity among the gear-type axles and the separate position of the worm type, in which these losses are not only greater over the whole range of the input torque, but increase more rapidly with an increasing torque. That neither the temperature nor the speed has any material influence on the load losses is clear from the fact that all points fall on or very close to the curves plotted. As the ratios of these axles differ, comparison on the basis of the torque input and loss is not entirely permissible. However, Fig. 21 shows the input torque, representing for each axle a wheel torque of 161,500 lb-in. when the losses in the axle are ignored. The corresponding torque-loss has been converted into a horsepower loss at a wheel speed of 2.5 m.p.h. in each case, thus establishing a better basis for comparison. The

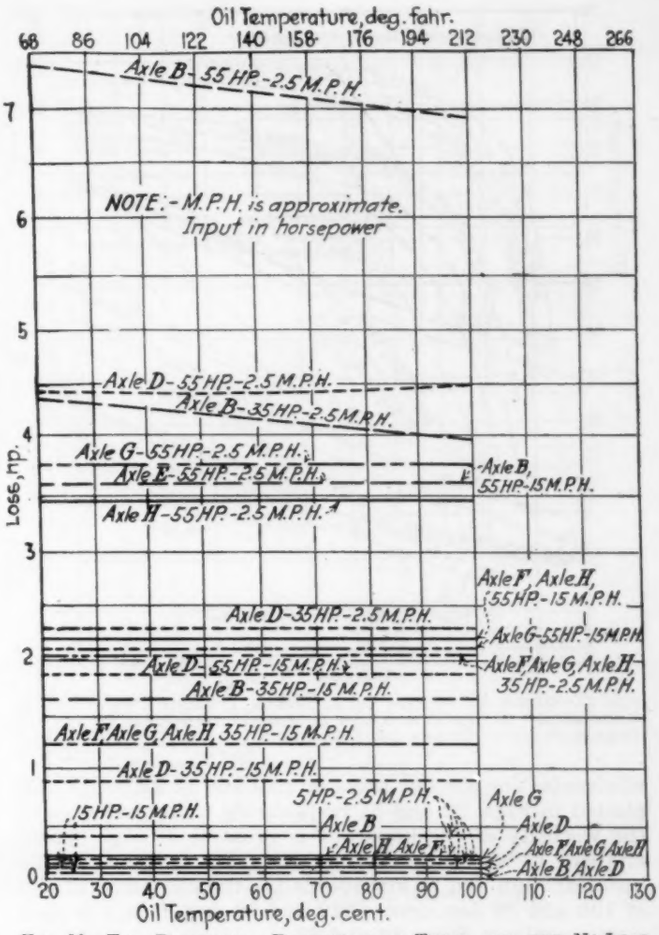

Oil Temperature, deg. fahr.
Axle B-55 HP.-2.5 M.P.H.
NOTE:-M.P.H. is approximate. Input in horsepower
Axle D-55 HP.-2.5 M.P.H.
Axle B-35 HP.-2.5 M.P.H.
Axle G-55 HP.-2.5 M.P.H.
Axle E-35 HP.-2.5 M.P.H.
Axle B, 55 HP.-15 M.P.H.
Axle H-55 HP.-2.5 M.P.H.
Axle F, Axle H, 55 HP.-15 M.P.H.
Axle D-35 HP.-2.5 M.P.H.
Axle G-55 HP.-15 M.P.H.
Axle D-55 HP.-15 M.P.H.
Axle F, Axle G, Axle H, 35 HP.-2.5 M.P.H.
Axle B-35 HP.-15 M.P.H.
Axle F, Axle G, Axle H, 35 HP.-15 M.P.H.
Axle D-35 HP.-15 M.P.H.
5 HP.-2.5 M.P.H.
15 HP.-15 M.P.H.
Axle G
Axle B
Axle D
Axle H, Axle F
Axle F, Axle G, Axle H
Axle B, Axle D
Loss, hp.
Oil Temperature, deg. cent.

FIG. 20—THE DIFFERENCE BETWEEN THE TOTAL AND THE NO-LOAD LOSSES PLOTTED AGAINST THE OIL TEMPERATURE WITH A VARYING HORSEPOWER INPUT AT THE HIGHEST AND THE LOWEST SPEEDS

total losses for the various axle types then represent the sum of these, widely and independently varying no-load and "load" losses.

Summaries of the total losses and the corresponding

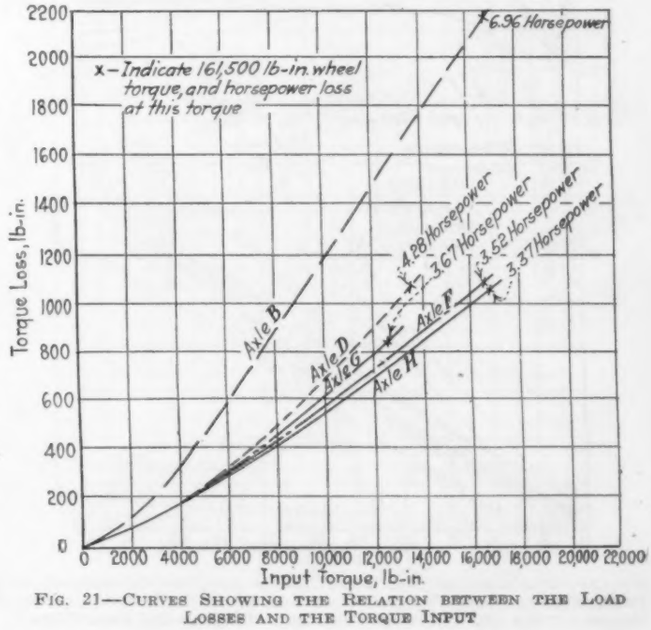


FIG. 21—CURVES SHOWING THE RELATION BETWEEN THE LOAD LOSSES AND THE TORQUE INPUT

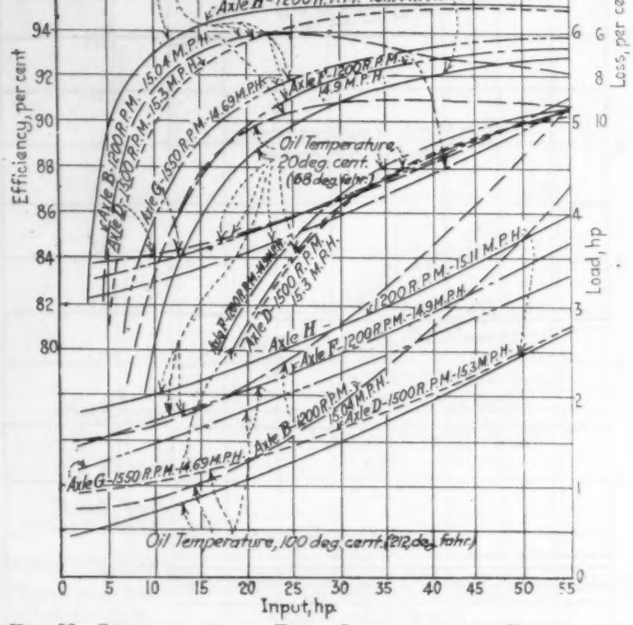

Oil Temperature, 100deg cent (212deg fahr)
Axle H-1200 R.P.M.-15.11 M.P.H.
Axle B-1200 R.P.M.-15.04 M.P.H.
Axle F-1200 R.P.M.-14.9 M.P.H.
Axle G-1550 R.P.M.-14.69 M.P.H.
Axle D-1500 R.P.M.-15.3 M.P.H.
Oil Temperature, 20deg. cent. (68 deg. fahr.)
Axle H-1200 R.P.M.-14.9 M.P.H.
Axle F-1200 R.P.M.-15.3 M.P.H.
Axle D-1500 R.P.M.-15.3 M.P.H.
Axle B-1200 R.P.M.-15.04 M.P.H.
Axle G-1550 R.P.M.-14.69 M.P.H.
Oil Temperature, 100 deg. cent. (212 deg. fahr.)
Efficiency, per cent
Load, hp
Loss, per cent
Input, hp.

FIG. 22—SUMMARY OF THE TOTAL LOSSES AND THE CORRESPONDING EFFICIENCIES OF THE FIVE AXLES AT A SPEED OF 15 M.P.H. AND OIL TEMPERATURES OF 20 AND 100 DEG. CENT. (68 AND 212 DEG. FAHR.)

efficiencies for the five axles at 15.0 and at 2.5 m.p.h. are plotted in Figs. 22 and 23 respectively. The influence of the viscosity of the lubricant is greatest at high speeds and can be seen best in Fig. 22. The relation of the losses at high and at low speeds for the oil temperatures of 100 and 20 deg. cent. (212 and 68 deg. fahr.) is seen most readily in Figs. 24 and 25.

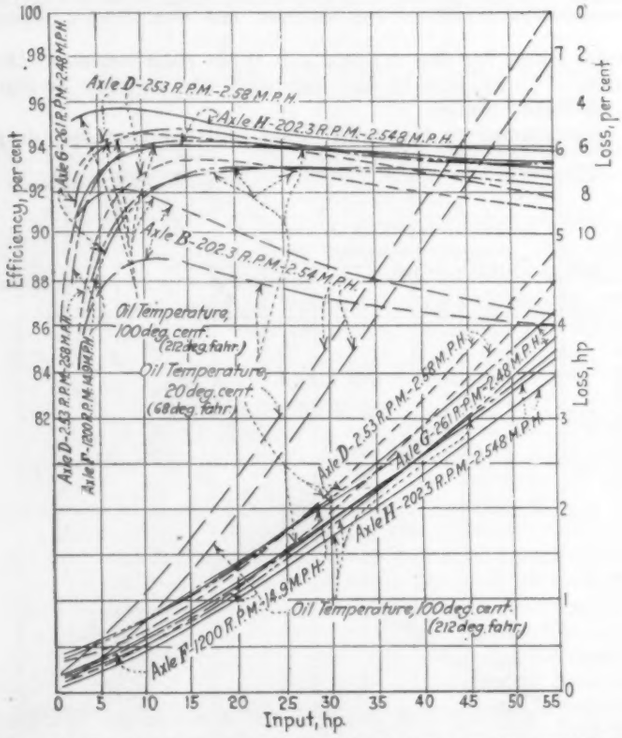

Axle D-253 R.P.M.-2.58 M.P.H.
Axle H-202.3 R.P.M.-2.548 M.P.H.
Axle G-261 R.P.M.-2.48 M.P.H.
Axle B-202.3 R.P.M.-2.54 M.P.H.
Oil Temperature, 100deg. cent. (212deg. fahr.)
Oil Temperature, 20deg. cent. (68deg. fahr.)
Axle F-1200 R.P.M.-14.9 M.P.H.
Oil Temperature, 100deg. cent. (212deg. fahr.)
Efficiency, per cent
Loss, hp
Loss, per cent
Input, hp.

FIG. 23—SUMMARY OF THE TOTAL LOSSES AND THE CORRESPONDING EFFICIENCIES OF THE FIVE AXLES AT A SPEED OF 2.5 M.P.H. AND OIL TEMPERATURES OF 20 AND 100 DEG. CENT. (68 AND 212 DEG. FAHR.)

The change in the total losses with the temperature for a 5 and a 55-hp. input at high and at low speed is plotted in Fig. 26. In Figs. 27 and 28, we have plots illustrating more conveniently the ratio between the total and the no-load losses and the influence of the speed on these losses and their relation to each other. The upper curve of each pair, as indicated, represents the total loss; the distance between the curves of a pair

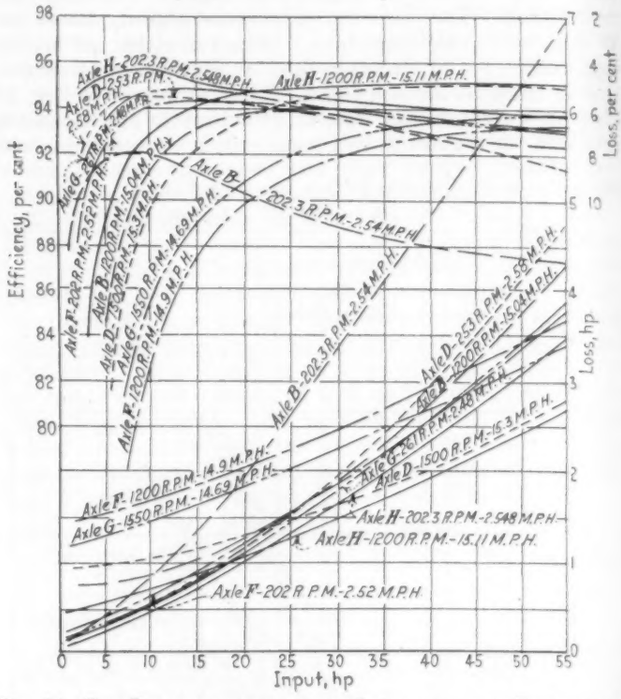


FIG. 24—THE RELATION BETWEEN THE LOSSES AND THE EFFICIENCIES OF THE FIVE AXLES AT HIGH AND LOW SPEEDS AND AN OIL TEMPERATURE OF 100 DEG. CENT. (212 DEG. FAHR.)

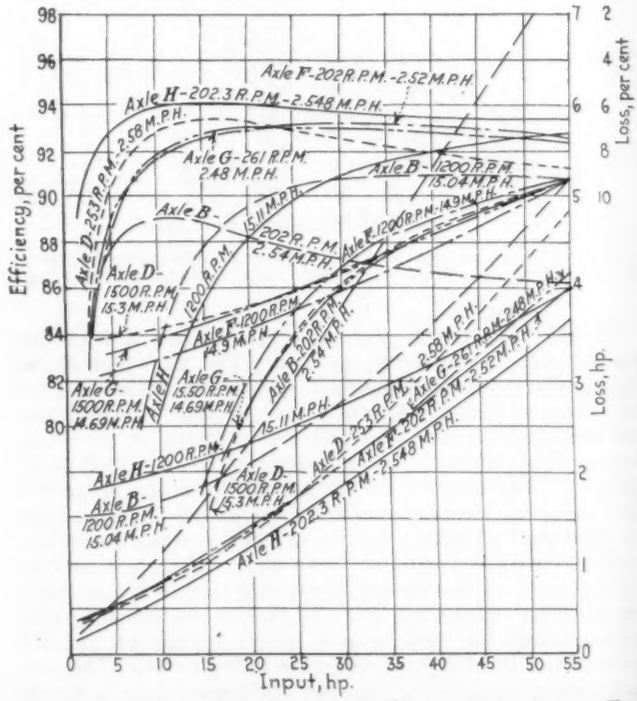


FIG. 25—CURVES OF THE LOSSES AND EFFICIENCIES OF THE FIVE AXLES AT HIGH AND LOW SPEEDS AND AN OIL TEMPERATURE OF 20 DEG. CENT. (68 DEG. FAHR.)

shows the no-load loss. The changes in the losses due to the varying influence of the no-load and the load losses, as well as the preponderance of one or the other of these for varying speed and load, are found readily here; also, the wide differences as between axles and the very unsatisfactory balance that certain axles show in the relation of the no-load to the load losses.

In Fig. 29, each axle is represented by two curves showing the power loss as changing with the input torque, for high speed in conjunction with low temperature and for low speed with high temperature, respectively. For the axle covered, these curves are the limiting lines between which the values for all other combinations fall. The power loss for torque inputs of 500, 10,000 and 17,000 lb-in. as governed by the speed is

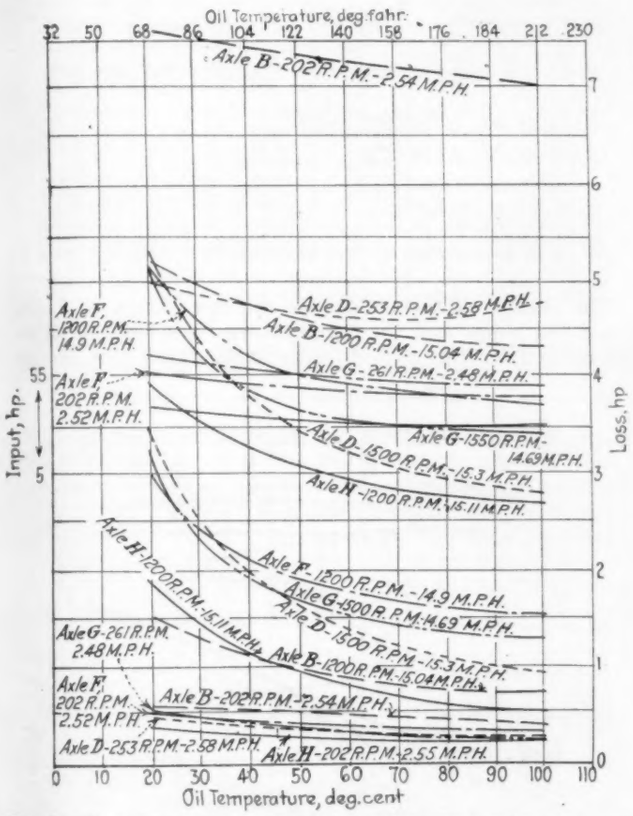

Oil Temperature, deg. fahr.
32 50 68 86 104 122 140 158 176 184 212 230
Axle B-202 R.P.M.-2.54 M.P.H.
Axle F 1200 R.P.M. 14.9 M.P.H.
Axle D-253 R.P.M.-2.58 M.P.H.
Axle B-1200 R.P.M.-15.04 M.P.H.
Axle F 202 R.P.M. 2.52 M.P.H.
Axle G-261 R.P.M.-2.48 M.P.H.
Axle G-1550 R.P.M.-14.69 M.P.H.
Axle D-1500 R.P.M.-15.3 M.P.H.
Axle H-1200 R.P.M.-15.11 M.P.H.
Axle H-1200 R.P.M.-15.11 M.P.H.
Axle F-1200 R.P.M.-14.9 M.P.H.
Axle G-1500 R.P.M.-14.69 M.P.H.
Axle G-261 R.P.M. 2.48 M.P.H.
Axle D-1300 R.P.M.-15.3 M.P.H.
Axle B-1200 R.P.M.-15.04 M.P.H.
Axle F 202 R.P.M. 2.52 M.P.H.
Axle B-202 R.P.M.-2.54 M.P.H.
Axle D-253 R.P.M.-2.58 M.P.H.
Axle H-202 R.P.M.-2.55 M.P.H.
Input, hp.
Loss, hp.
55
5
0 10 20 30 40 50 60 70 80 90 100 110
Oil Temperature, deg. cent

FIG. 26—THE CHANGE IN THE TOTAL LOSSES FOR INPUTS OF 5 AND 55 HP. AT HIGH AND LOW SPEEDS PLOTTED AGAINST THE OIL TEMPERATURE

plotted in Fig. 30. The maximum and minimum losses and efficiencies for each axle, including all five test-speeds and temperatures of 20, 40, 70 and 100 deg. cent. (68, 104, 158 and 212 deg. fahr.), are plotted in Fig. 31. It is interesting to note here the similarity in losses and the range covered by the three axles with lubricant in the wheels. The high limit of the losses, being at high speed and 20 deg. cent. (68 deg. fahr.), is closely similar; the low-limit lines spread considerably for the higher loads. The wide difference between Axles *B* and *H* is also noticed at once.

The loss and the efficiency curves of any one axle, as shaped by various influences, cross to such an extent that it becomes more convenient to use for a comparison the means of the losses and the efficiencies combined for individual or for several temperature and speed conditions. Such a combination is given in Fig. 32; the curves include all five speeds from 15.0 to 2.5 m.p.h. One set

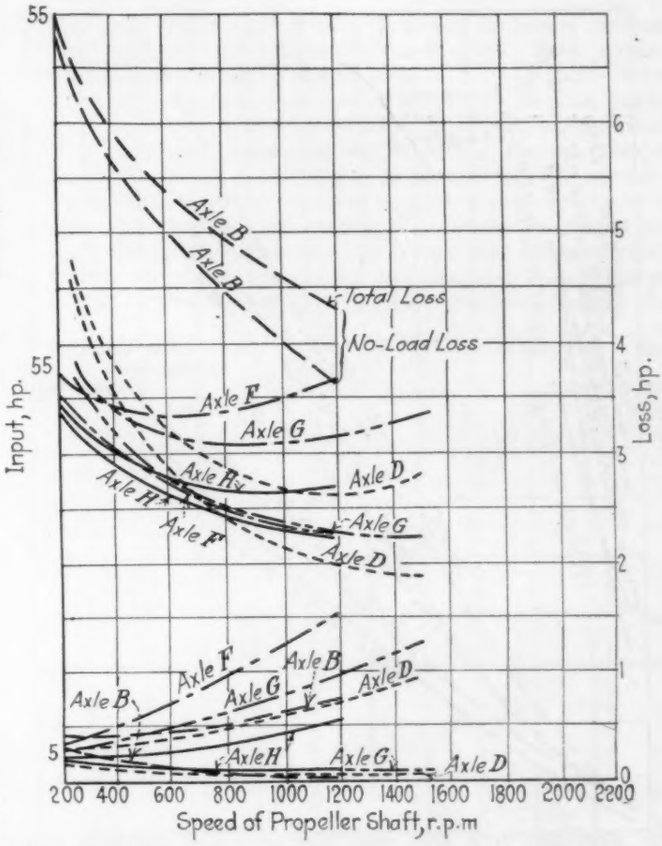


FIG. 27—CURVES OF THE TOTAL AND NO-LOAD LOSSES PLOTTED AGAINST THE PROPELLER-SHAFT SPEED AT AN OIL TEMPERATURE OF 100 DEG. CENT. (212 DEG. FAHR.)

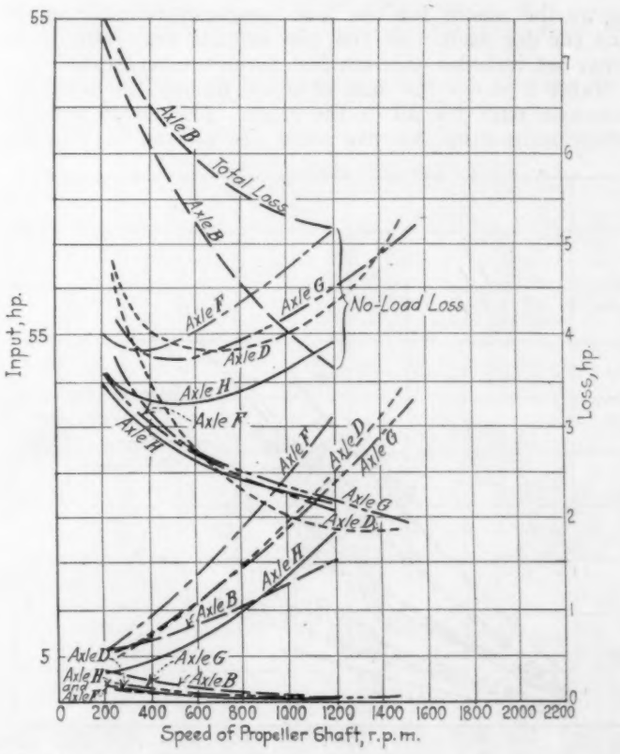


FIG. 28—RELATION BETWEEN THE TOTAL AND NO-LOAD LOSSES AND THE INFLUENCE OF THE SPEED UPON THESE LOSSES AT AN OIL TEMPERATURE OF 20 DEG. CENT. (68 DEG. FAHR.)

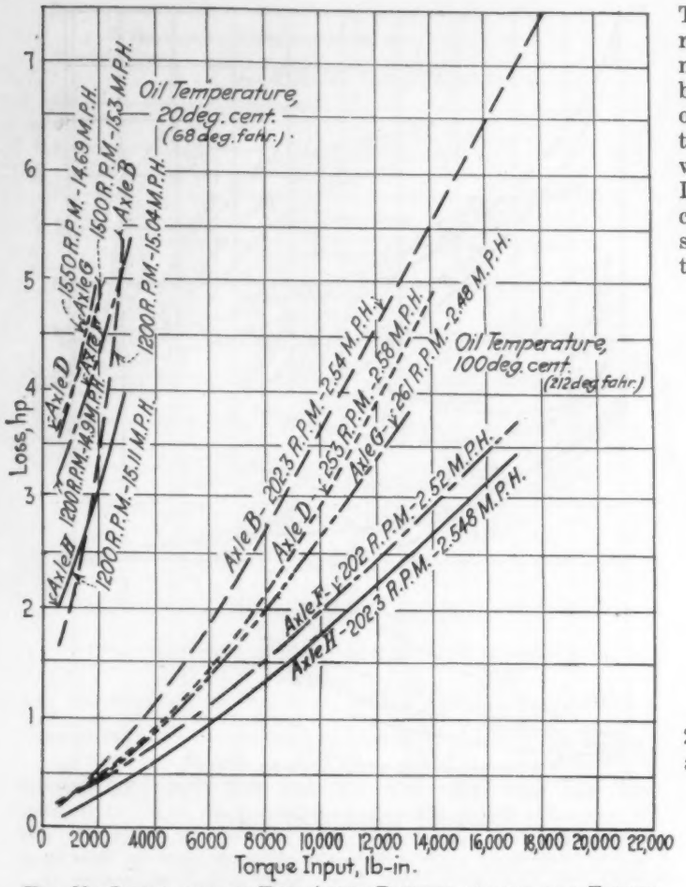


FIG. 29—LOSSES OF THE FIVE AXLES PLOTTED AGAINST THE TORQUE INPUT AT DIFFERENT SPEEDS AND TWO OIL TEMPERATURES

shows the means for the four temperatures, 20, 40, 70 and 100 deg. cent. (68, 104, 158 and 212 deg. fahr.); the other set includes only the last three temperatures.

Table 1 shows the data obtained during the temperature-rise runs for all of the axles. The losses and the temperature-rises for five axles are plotted in Fig. 33.

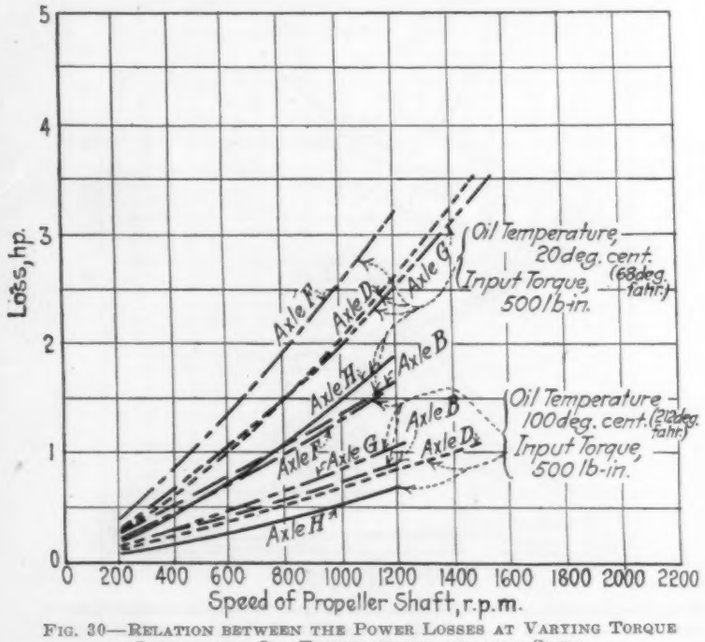


FIG. 30—RELATION BETWEEN THE POWER LOSSES AT VARYING TORQUE INPUTS AND OIL TEMPERATURES AND THE SPEED

The temperature-rises at the time when equilibrium is reached range fairly well with the losses. It will be noted that in Axle *A* the temperature-rise at the rear bearing is closely similar to that in the sump under these operating conditions. In Axle *B*, however, the rise at the bearing is somewhat less than in the sump. This will be referred to in connection with the endurance run. During this test with Axle *C* a number of stoppages occurred, caused by interruptions in the electric power-supply; but, as these did not affect the result materially, the test was continued.

TABLE 1—TEMPERATURE-RISE RUN AT 15 M.P.H.

Axle	Input		Time			Temperature Equilibrium					
						Oil		Room		Rise	
	H.p.	Torque, Lb-In.	Hr.	Min.		Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
A	49.5	2,600	2	20	Sump	108.0	226.4	21.5	70.7	87	156.6
					Bearing	107.5	225.5	21.5	70.7	84	151.2
B	50.0	2,620	3	30	Sump	101.0	213.8	21.5	70.7	82	147.6
					Bearing	86.0	186.8	21.5	70.7	68	122.4
C	50.5	2,640	3	30	Sump	96.0	104.8	23.0	73.4	82	147.6
					Bearing	91.0	195.8	23.0	73.4	78	140.4
D	50 5	2,160	4	00	.....	84.0	183.2	26.0	78.8	56	100.8
F	51.0	2,660	4	20	.....	88.0	190.4	23.0	73.4	72	129.6
G	50.0	2,030	4	15	.....	93.0	199.4	21.5	70.7	80	144.0
H	50.5	2,625	4	20	.....	80.0	176.0	24.0	75.2	58	104.4

The results of the endurance run are shown in Table 2 and the losses and the temperature-rises for five axles are plotted in Fig. 34. A remarkably rapid rise in the

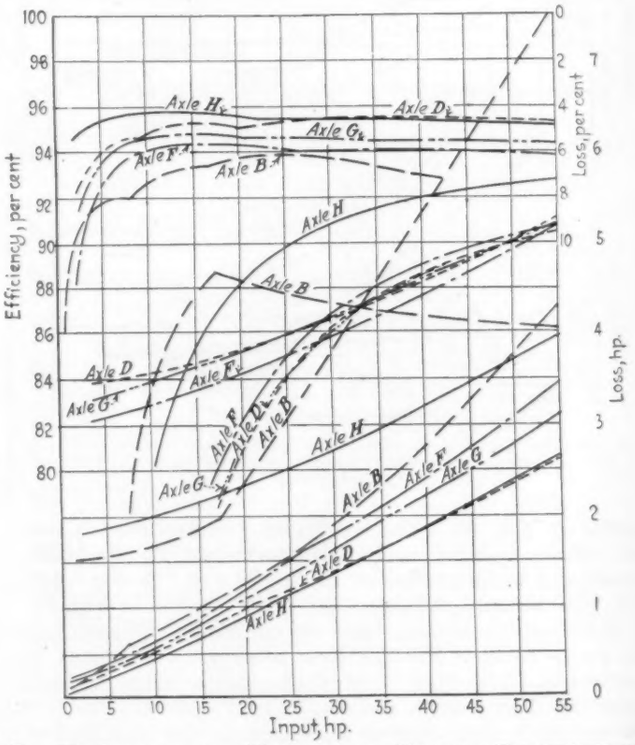


FIG. 31—CURVES OF THE MAXIMUM AND MINIMUM EFFICIENCIES OF THE FIVE AXLES AT FIVE DIFFERENT SPEEDS AND FOUR OIL TEMPERATURES

oil temperature in the Class-B axles *A*, *B* and *C* will be noted. In axle *A*, this applies particularly to the rise observed at the rear bearing, which is lubricated by the oil coming from the worm. In Axles *B* and *C*, the temperature-rise at the bearing is considerably less than in the sump. The explanation of this lies in the course taken

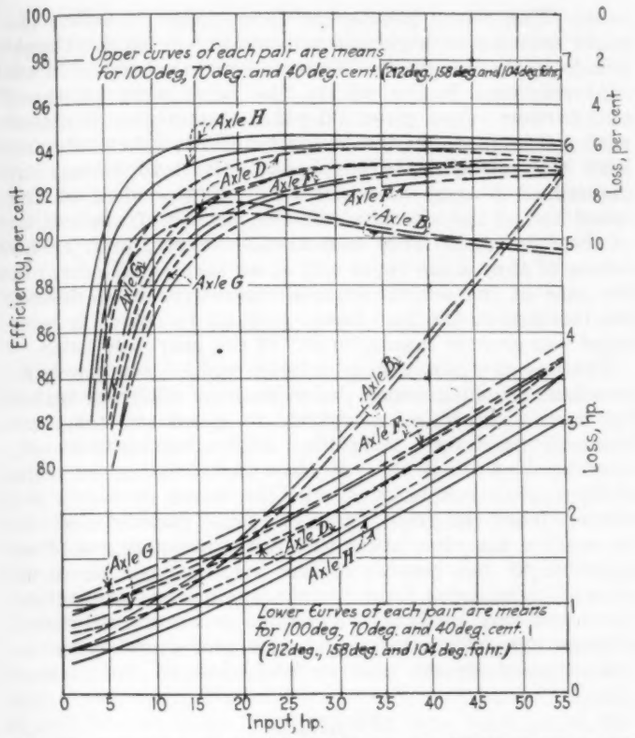

Upper curves of each pair are means for 100deg. 70deg. and 40deg. cent. (212deg., 158deg. and 104deg. fahr.)
Axle H
Axle D
Axle E
Axle F
Axle B
Axle G
Lower curves of each pair are means for 100deg., 70deg. and 40deg. cent. (212deg., 158deg. and 104deg. fahr.)
Efficiency, per cent
Loss, per cent
Loss, hp.
Input, hp.

FIG. 32—SUMMARY OF THE MEAN LOSSES AND EFFICIENCIES OF THE FIVE AXLES FOR FIVE DIFFERENT SPEEDS AND FOUR OIL TEMPERATURES

by the oil after leaving the worm, where it is heated; most of the oil from the worm returns directly into the sump, causing a more rapid temperature-rise at this point. The greater length occupied by the bearings, and the greater heat-dissipating capacity of the larger housing-end, further account for the lower temperature observed at this point during this run and the temperature-rise run.

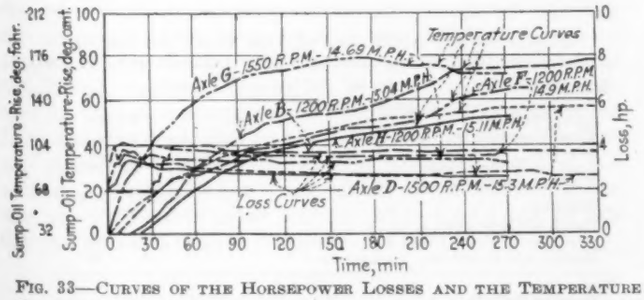


FIG. 33—CURVES OF THE HORSEPOWER LOSSES AND THE TEMPERATURE RISES FOR THE FIVE AXLES WITH AN INPUT OF APPROXIMATELY 50 HP. AT THE HIGHEST SPEED

In Axles *D*, *E*, *F* and *G*, the distribution of the losses as between the central housing and the two wheels would be expected to result in a smaller temperature-rise compared with axles in which practically all the loss is concentrated in the central housing. A lower rise of the sump temperature for a similar loss can be expected in those axles in which a part of the loss takes place in the wheels. The variations in the operating conditions during the endurance runs with several of the axles are explained in the Appendix.

POSSIBILITIES OF IMPROVEMENT

It is evident that the use of a lubricant with a lower viscosity at low temperatures would tend to improve the efficiency of Axles *D*, *F* and *G*, under the more unfavorable conditions of temperature and speed. Such a lubricant would also be of aid in Axle *H*, though there is less room for such improvement in that case. With a knowledge of the viscosity of such a lubricant as compared with that used here, the means of the losses shown in Fig. 32 will be of assistance in estimating the improvement that might be expected in such a case, with any of the axles tested. Of course, it is understood that any such lubricant would have to be no less efficient at the higher temperatures and the heavier pressures occurring at the larger input-torque values. Another feature that

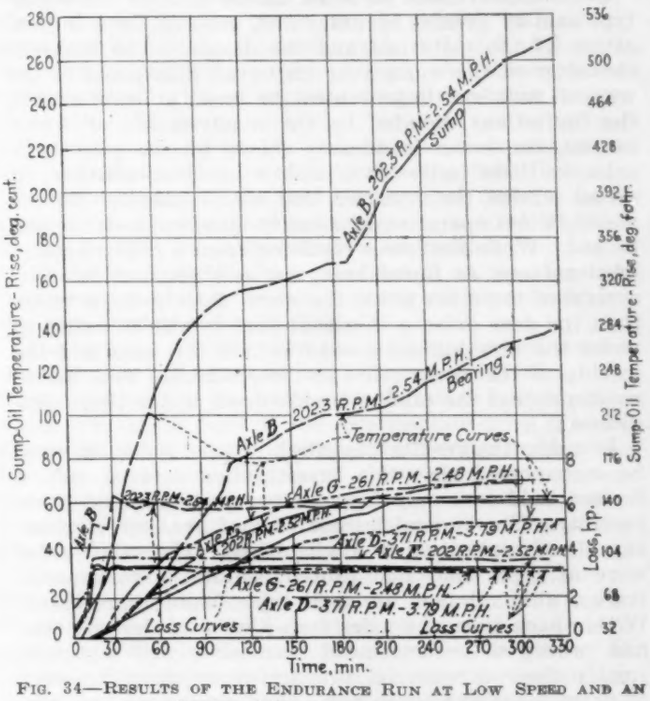


FIG. 34—RESULTS OF THE ENDURANCE RUN AT LOW SPEED AND AN INPUT OF APPROXIMATELY 50 HP.

TABLE 2—ENDURANCE RUN AT 2.5 M.P.H.[4]

Axle	Input Hp.	Input Torque, Lb-In.	Time Hr.	Time Min.		Temperature Oil Deg. Cent.	Temperature Oil Deg. Fahr.	Temperature Room Deg. Cent.	Temperature Room Deg. Fahr.	Temperature Rise Deg. Cent.	Temperature Rise Deg. Fahr.	Total Time, Full Load Hr.	Total Time, Full Load Min
A	48.0	15,000	1	40	Sump	140	284	20	68.0	124	223.2	1	40
					Bearing	385	725	20	68.0	369	664.2		
B	48.0	15,000	4	00	....	....	....	....	....	....	....	13	20
	50.0	15,600	1	20	....	....	....	....	....	....	....		
	50.0	15,600	5	00	Sump	293	559.4	23	73.4	287	516.6		
					Bearing	162	323.6	23	73.4	140	252.0		
	50.0	15,600	3	00	....	....	....	....	....	....	....		
	50.0	15,600	4	20	....	....	....	....	....	....	....		
C	50.0	15,600	5	15	Sump	303	577.4	24	75.2	281	505.8	12	40
					Bearing	186	366.8	24	75.2	164	295.2		
	50.0	15,600	3	5	....	....	....	....	....	....	....		
D	50.0	8,500	5	10	....	84	183.2	28	82.4	78	140.4	9	55
	50.0	8,500	4	45	....	....	....	....	....	....	....		
	47.0	10,700	5	5	....	110	230.0	30	86.0	82	147.6		
	47.5	10,800	5	5	....	....	....	....	....	....	....		
E	51.0	11,600	4	20	....	....	....	....	....	....	....	21	10
	51.0	11,600	4	10	....	....	....	....	....	....	....		
	55.0	12,400	2	30	....	....	....	....	....	....	....		
F	49.5	15,500	5	00	....	89	192.2	20	68.0	73	131.4	13	50
	49.5	15,500	5	00	....	....	....	....	....	....	....		
	52.0	16,200	3	50	....	....	....	....	....	....	....		
G	44.5	10,750	4	30	....	93	199.4	24	75.2	75	135.0	8	30
	47.0	11,400	4	00	....	....	....	....	....	....	....		
	49.0	15,300	5	00	....	87	188.6	25	77.0	64	115.2		
	49.0	15,300	5	00	....	....	....	....	....	....	....		
H	51.5	16,000	5	00	....	....	....	....	....	....	....	23	30
	51.5	16,000	2	10	....	....	....	....	....	....	....		
	51.5	16,000	6	20	....	....	....	....	....	....	....		

[4]For Axle *D*, the speed was 3.79 m.p.h.

suggests itself as capable of improvement is the means used for circulating the lubricant; the present method appears at the higher speeds and viscosity to be an exceedingly unsatisfactory one from the viewpoint of efficiency. It seems somewhat doubtful whether it is desirable to direct a large volume of the oil from the worm to the bearings. The latter might be provided for better by a smaller quantity of oil of lower temperature delivered directly from the sump. A generous-sized central-housing, assuring an ample supply of lubricant without necessitating deep immersion of revolving parts, would be an advantage.

Some improvement no doubt can be made in the worm-type axle by greater accuracy and, possibly, by a modification of the materials and the design. The inherent character of the worm gear may even then stand in the way of sufficient improvement to meet, at least within the limitations dictated by the requirements of Army service, the lower load-losses shown by the gear-drive axles in these tests. It is also a question whether, in actual service, the attention that seems essential for the most efficient operation of a heavy-duty worm-drive, can be had. While the losses resulting from a high-viscosity lubricant are, as found here, not as objectionable as in several of the other axles, the worm drive requires more than the gear drive a lubricant that is able to stand-up under the very highest pressures; for the wear and the scoring of the worm gears in the endurance runs leaves no doubt that the oil-film breaks-down under these conditions.

In using the results described in this paper, it must be remembered that this investigation covered only a limited field and only heavy-duty truck-axles of 5-ton capacity. The general lessons learned are, nevertheless, capable of application in a wider field. The axles tested were of types that had proved useful for commercial trucks, although not all such types were represented. Within each type, the axles tested were of designs that had proved or recommended themselves sufficiently to justify their commercial production by manufacturers of prominence and experience. The worm-type axle was the joint product of the most experienced designers and manufacturers in the field, and it was designed especially for the severe conditions of Army service; this, however, limited the worm gear to proportions that were not the best for most efficient operation. On the other hand, the axles tested do not each represent, necessarily, the most efficient that can be produced of each type; nor do the results obtained permit the conclusion that, in axles of different capacity although apparently similar design, the same relations of efficiency necessarily will prevail. Mechanical efficiency finally is but one of several features, a compromise among which is necessary for every axle. It is, however, a very important feature.

It is hoped that the results of this investigation will, in addition to forwarding the development of efficient axles for Army use, prove of value to the automotive industry generally. These are the two objects that animated the Motor Transport Division in requesting the Bureau of Standards to undertake this work.

Summary

The investigation covered a number of heavy-duty truck-axles representing the several types in successful use. In analyzing the results of the tests it was found possible to separate the losses into no-load losses and load losses, the total loss being the sum of these two. In general, the no-load losses were controlled primarily by the viscosity and the method of application of the lubricant. They were greater in those axles in which the parts rotating at high speeds were immersed most completely in the lubricant. Where a separate body of lubricant was used in the wheels, the losses were increased still further. In a given axle, these losses also increased with an increase in the viscosity of the lubricant, and with the propeller-shaft speeds. The load losses, expressed as torque, were practically independent of the speed and of the viscosity and the method of application of the lubricant. They increased, however, with an increase of the torque input and at an increasing rate. In the case of the several Class-B worm-type axles tested, the increase in the load losses with an increased torque-input was greater than with any of the gear-type axles.

The use of a lubricant of a lower viscosity at low temperatures would improve the mechanical efficiency under the more unfavorable conditions of speed and temperature and would seem advisable. Such a lubricant should, however, be no less efficient than that used in the tests at the higher temperatures and the heavy pressures resulting from the high torque-values. Improvement in the method for circulating the lubricant is suggested as desirable by the results, as the high no-load losses of some of these axles show the present method of circulation to be very inefficient. The characteristic difference between the worm-drive and the gear-drive types is demonstrated by the greater load-losses of the former type.

APPENDIX

This appendix serves as a record of such mechanical particulars of the axles as are of interest in connection with this paper, of deviations that occurred from the regular test program and of other features of interest in a study of the results. The reasons that led to the selection of Axle *B* to represent the worm type in the summary are explained also.

Class-B Army Axles

In general, the axle and the additional worm and differential-carrier assemblies furnished the Bureau were new parts taken from the Motor Transport Division stock at its Camp Holabird, Md., depot and can be fairly taken as representative material. Sectional views of this axle are shown in Fig. 1, while Fig. 2 shows the worm assemblies as used with ball bearings in Axles *B* and *C*, respectively. The specifications for the worm and gears are, in the main, as stated in Table 3. The same housing, wheels and wheel bearings were used for all the Class-B axles tested.

TABLE 3—SPECIFICATIONS FOR THE WORM AND GEARS

Worm:	
Number of Threads, Right-Hand	4
Linear Pitch, in.	1.1562
Pitch Diameter, in.	3.2650
Lead, in.	4.6250
Lead Angle, deg., min.	24 16
Pressure Angle, deg.	30
Material	S.A.E. No. 3120 Steel
Depth of Carbonization, in.	3/64
Hardness of Worm Threads, Scleroscope	70 to 85
Hardness of Remainder, Scleroscope	40 to 50
Worm Gear:	
Number of Teeth	38
Pitch Diameter, in.	13.985
Throat Diameter, in.	14.655
Material	Best Grade of Gear Bronze, Chilled Castings
Copper, per cent	89
Tin, per cent	11
Tensile-Strength, lb. per sq. in.	35,000 to 40,000
Brinell Hardness	70 to 95

The Motor Transport Division had available a considerable supply of worm housings, equipped with ball bearings, considered an alternative standard, shown in the upper portion of Fig. 2, and requested the testing of an axle thus equipped, Axle *B*, to secure, if possible, a comparison with the same type of axle with tapered-roller bearings that has constituted the primary standard design, Axle *A*. In view of the increasing use of annular ball bearings in place of ball-thrust washers and their lower cost and the smaller number of parts, one axle thus equipped, Axle *C*, shown in the lower portion of Fig. 2, was also included among those tested.

Axle *A*

This standard Class-B Army-truck axle was equipped throughout with tapered-roller bearings. A thermocouple for observing the temperature of the sump oil was inserted through the drain-plug. A second thermocouple projected through a hole drilled in the rear-end cover-plate of the worm housing into the space behind the rear bearing so as to register the temperature of the oil where it leaves the cored duct, carrying it from a trough next to the worm to the rear bearing. This bearing, in addition to supporting the radial load on this end of the worm shaft, takes the whole worm-thrust in forward operation. As this axle was the first one tested, the test program differed from that described earlier in several respects. The efficiency tests were made only at 40 and 80 deg. cent. (104 and 176 deg. fahr.), and no tests were made at 12.5 or 1.7 m.p.h. The check-runs were made at 80 deg. cent. (176 deg. fahr.) and the losses at no-load were not ascertained.

Axle *B*

This Class-B Army-truck axle was equipped with single-row annular ball-bearings for the radial support of the worm; the thrust was taken by double ball-thrust washers, mounted as shown in the upper portion of Fig. 2. The differential was carried in tapered-roller bearings of a type differing from those in Axle *A*. One thermocouple was inserted through the drain-plug into the sump, while a second thermocouple projected through the rear-end cover-plate of the worm housing, as indicated in Fig. 8, and was located ½ in. behind the rear ball-thrust washer. The latter bearing takes the thrust-load in forward operation. The test program differed from the one described in the following details: No test was made at 12.5 m.p.h., but the efficiency tests at 8.5 and at 4.6 m.p.h. were made at all three temperatures. The check-run was made only at 15.0 m.p.h. and at 100 deg. cent. (212 deg. fahr.).

Axle *C*

In this otherwise standard Class-B Army-truck axle, the worm was supported by three single-row annular ball-bearings of the same type and size used in Axle *B* for the radial load. These bearings are mounted in the manner shown in the lower portion of Fig. 2; the fits and the clearances of the rear bearings provide that one of these can take only the radial load and the other only the thrust. The use of the standard housing necessitated the addition of the bushings and spacers shown. The differential was carried in tapered-roller bearings of the same type as used in Axle *A*. The location of the thermocouples was similar to that in Axle *B*, one thermocouple being inserted through the drain-plug and the other at the rear of and about ½ in. from the thrust bearing. The test program differed from the one described in the following details. Efficiency tests at 8.5 m.p.h. were made at all three test-temperatures, but no tests were made at 12.5 m.p.h.

Axle *D*

Axle *D*, shown in Figs. 3 and 4, is of three-stage "double-reduction" gear-drive type. The central housing contains the bevel-gear reduction and the differential, the bevel gears having respectively 16 and 40 teeth of 4 pitch and the differential. The axle shafts passing centrally through the load-bearing axle-housing each carry at the wheel-end a 12-tooth spur-gear pinion that, through one intermediate drive-pinion with 22 teeth engaging with a 56-tooth internal-gear ring in each wheel, transmits the power to the wheel. All wheel gears are 3½ pitch. The axle ratio is 11 2/3 to 1, and the axle is regularly employed in a well-known 5-ton truck equipped with an engine giving a maximum torque of about 2180 lb-in. with the low-gear transmission-ratio employed, 4.1 to 1. This results in a maximum input-torque at the axle of not exceeding 8500 lb-in.

When considering the test results and certain deviations from the standard test-program, it must be kept in mind that the manufacturer in making this axle available for tests did not represent it as meeting the requirements of the Class-B Army-truck as covered by the specification given in Table 3.

The bearing equipment of this axle consists of single-row annular ball-bearings, with the exception of a ball-thrust washer for the bevel-gear thrust and one spiral-roller bearing in each of the intermediate-drive pinions where the space is very limited. Two thermocouples were inserted into the differential housing, one entering through the sump drain-plug; the second thermocouple, used as a check, entered through the oil filler-plug at the rear and extended into the body of the housing.

The test program differed from the one described in the following details. No test was made at 12.5 m.p.h. The endurance run with input of 50 hp. was made at a speed of 3.8 m.p.h., corresponding to 8500 lb-in. of torque, thus representing respectively the maximum power and torque conditions that can be imposed by the engine and the low gear-ratio with which it is used. This results, if the losses are ignored, in a torque of just under 100,000, lb-in. at the wheels. As the axle had not been tested previously at this speed, an efficiency test at 3.8 m.p.h. was made for checking purposes, just preceding the endurance run. During the progress of the endurance run, the Motor Transport Division requested that efficiency tests also be made with this axle equipped with a different bevel pinion and gear for a total axle-ratio of 13 1/3 to 1. The endurance test was therefore discontinued after two 5-hr. periods at full load to prevent a possible failure or more severe wear of the other parts for which no spares were available.

Axle *E*

This is a similar axle to Axle *D*, but fitted with a new bevel pinion and gear of respectively 14 and 40 teeth of pitch 4 for a total axle-reduction of 13 1/3 to 1, together with new pinion-shaft bearings. All else was left as before. The particulars given under Axle *D* in regard to the maximum input-power for which this axle is used by its manufacturer apply here as well.

In view of the tests made with Axle *D*, the schedule for the present axle was limited to a 3-hr. run at 8.1 m.p.h. with up to 23-hp. input, followed by a 2-hr. run at 2.5 m.p.h. with a similarly increasing power-input. Then followed efficiency tests at 15 m.p.h. with the oil temperature at 40, 70 and 100 deg. cent. (104, 158 and 212

TABLE 4—AVAILABLE DATA COMPARED WITH THE RESULTS FOR AXLE *D*; SIMILAR SPEED AT THE PROPELLER-SHAFT

Propeller-Shaft Speed, r.p.m.		High, 1,500		Low, 263	
Axle Ratio		13 1/3 to 1	11 2/3 to 1	13 1/3 to 1	11 2/3 to 1
Speed, m.p.h.		13.4	15.3	2.26	2.58
		Power Loss, HP.			
Input, hp.	10	1.98	2.06	0.58	0.63
	30	2.64	2.62	1.95	2.05
	50	3.44	3.51	4.02	4.16
Input Torque, lb-in.	500	2.03	2.08	.....	.....
	1,000	2.45	2.43	.....	.....
	2,000	3.33	3.38	.....	.....
Input Torque, lb-in.	2,000	.....	.....	0.50	0.53
	6,000	.....	.....	1.47	1.55
	12,000	.....	.....	3.80	3.94

deg fahr.) and at 2.5 m.p.h. at 40 and 100 deg. cent. (104 and 212 deg. fahr.). The endurance test then completed the series.

For the endurance run, the operating speed corrresponded to 2.48 m.p.h. and the first two 5-hr. periods were made with a power input of 47.5 hp., corresponding to 10,700 lb-in. of torque. Taking into account the axle ratio of 13 1/3 to 1 and ignoring the losses, the wheel torque figures 143,000 lb-in. as compared with 100,000 lb-in. for Axle *D*.

The limited efficiency-tests permit a comparison of the influence resulting from the change in the gear-ratio. The available data can be compared with the results for Axle *D* on the basis of either similar speed at the propeller-shaft or at the wheels. The values stated in Tables 4 and 5 are obtained by reducing the data in both of these ways.

From Table 4, it is seen that, on the basis of propeller-shaft speed in revolutions per minute for either the same horsepower or torque-input, the power losses do not vary much. Assuming the same wheel-speeds as in Table 5, the power losses are higher for the 13 1/3 to 1 axle-ratio for any given input-torque, and increase at a greater rate with an increasing horsepower-input at the low gear-speeds.

Axle *F*

Axle *F*, illustrated in Fig. 5 is another representative of the internal-gear type and manufactured for commercial trucks of 5-ton rating.

The cast housing, containing a bevel pinion and a gear of respectively 19 and 35 teeth of 3½ pitch and the differential, is located in front of the forged dead-axle. The jackshaft pinions of 14 teeth of 4/5 pitch engage with internal-gear rings with 73 teeth. The gear ring departs from the more usual practice by being welded to a spider, the hub of which, in turn, is bolted to the wheel hub. The total reduction ratio is 9.60. The bearing equipment is as follows: The pinion-shaft support consists of one single and one double-row annular ball-bearing; the differential is carried in two double-row ball-bearings. A single-row annular ball-bearing is mounted next to the jackshaft pinion, and each wheel is carried on two double-row ball-bearings. The housing does not extend in the usual manner to the wheels, but stops near the spring-pads where its ends are carried in spherical seated brackets for the purpose of relieving the strains otherwise set up by the distortion of the dead axle. Two torque braces prevent any rotation of the housing. This axle is designed for the use of oil instead of grease in the wheels, the design being modified with this in view. The standard test-lubricant was therefore used in the wheels as recommended by the axle manufacturer. Two thermocouples projected respectively through the sump drain-plug and the oil filler-hole in the rear of the housing. The test program was regular in all respects.

TABLE 5—AVAILABLE DATA COMPARED WITH THE RESULTS FOR AXLE *D*; SIMILAR SPEED AT THE WHEELS

Speed, m.p.h.		High, 15.30		Low, 2.58	
Axle Ratio		13 1/3 to 1	11 2/3 to 1	13 1/3 to 1	11 2/3 to 1
Propeller-Shaft Speed, r.p.m.		1,720	1,500	289	253
		Power Loss, HP.			
Input, hp.	10	2.38	2.06	0.78	0.63
	20	3.03	2.02	2.73	2.05
	30	3.94	3.51	5.47	4.16
Input Torque, lb-in.	500	2.50	2.08	.....	.....
	1,000	2.95	2.43	.....	.....
	2,000	4.12	3.38	.....	.....
Input Torque, lb-in.	2,000	.....	.....	0.60	0.53
	6,000	.....	.....	1.70	1.55
	12,000	.....	.....	4.25	3.94

Axle *G*

Axle *G* is an internal-gear type in regular production and is in use in commercial 5-ton trucks, as is shown in Fig. 6. The cast housing carrying the bevel pinion and a gear of respectively 16 and 39 teeth of 4 pitch is located in front of the forged dead-axle. The jackshaft pinions of 13 teeth, 4 pitch, engage with the internal-gear rings with 67 teeth. The total axle-ratio is 12.56 to 1. The manufacturer was unable to furnish the necessary parts for an axle ratio different from this.

The bearing equipment is as follows: The pinion shaft is carried on one spiral-roller bearing and one double-row annular ball-bearing; the differential is carried by two spiral-roller bearings each backed by a ball thrust-washer; the pinion end of the jackshaft has a spiral-roller bearing; the wheels are each mounted on one cylindrical solid-roller and one double-row annular ball-bearing. Two thermocouples were inserted into the differential housing, one entering the sump through the drain-plug; the other, used as a check, was inserted through a pipe-plug in an inspection-hole in the front of the central housing. As this axle is designed for the use of grease for lubricating the internal gears, a heavy graphite grease, Dixon No. 680, was used in line with the recommendation of the axle manufacturer.

The test program was the standard one except for a modification of the load in the endurance run on account of the different axle-ratio. Although guaranteed for a maximum torque-input of 20,000 lb-in. with the ratio of 12.56 to 1, this ratio, higher than the range of interest to the Army, might be lowered readily by the substitution of a different bevel pinion and gear. The axles with ratios within the desired range were loaded during the endurance run with about 90 per cent of the specified maximum torque-input of 17,000 lb-in. The manufacturer of this axle furthermore listed an optional ratio of 10 to 1, though he had not found any call for it. It was found that, if the test axle with a ratio of 12.56 to 1 were subjected to about 11,000 lb-in. of input torque, the gears would on the average be loaded to closely the same average amount as would be the case with 90 per cent of 17,000 lb-in. of torque applied to this axle if equipped with a ratio of 10 to 1; the bevel pinion would then carry about 5 per cent overload and all other gears would be underloaded about 12 per cent. The

wheel torque would be about 5 per cent less than that of the axles with 9.5 ratios during the similar tests.

Axle *H*

Axle *H*, a triple-reduction type with all gears located in the central housing, differs considerably in design from the more conventional types as seen from the sectional views in Figs. 7, 8 and 9. In single-reduction-type axles with bevel or worm drive, it is the general practice to locate the differential on the axle shafts, although, in a few cases, it has been placed on the primary shaft. In the internal-gear and in some double-reduction axles having all gears in the central housing, the differential is on the secondary shaft. One of the principal features of Axle *H* lies in the location of the differential on the primary shaft.

Two spur-gear reductions 13 to 23 teeth, 4/5 pitch, to the first intermediate shafts are followed by bevel drives of 18 to 36 teeth of the same pitch between these and the second intermediate shafts and the final spur-gear drives with 12 and 32 teeth, 3/4 pitch, to the axle shafts. The total axle-ratio is 9.44 to 1.

The bearings throughout were annular ball-bearings of the single and double-row types, the latter being used where thrust loads occur. Two thermocouples were used in the central housing, one projected through the drain-plug and the other, used as a check, was inserted through one of the cover bolts in the right front corner of the housing and reached about half-way down. The test program differed but slightly from that already described. In view of the slight change in the losses with the oil temperature at the lower speeds, the tests at 4.5 and 2.5 m.p.h. were made at 40 and at 100 deg. cent. (104 and 212 deg. fahr.).

Explanatory Notes

It is desired to record and explain a few departures from the observed values of the losses in the plots

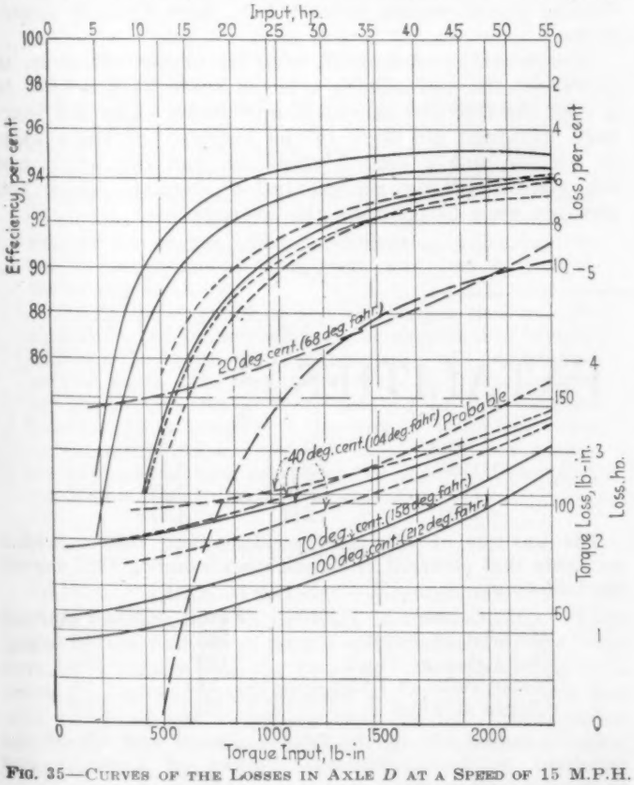

Input, hp
Efficiency, per cent
Loss, per cent
Torque Loss, lb-in.
Loss, hp.
Torque Input, lb-in
20 deg. cent. (68 deg. fahr.)
40 deg. cent. (104 deg. fahr.) Probable
70 deg. cent. (158 deg. fahr.)
100 deg. cent. (212 deg. fahr.)

Fig. 35—Curves of the Losses in Axle *D* at a Speed of 15 M.P.H. and an Oil Temperature of 40 Deg. Cent. (104 Deg. Fahr.)

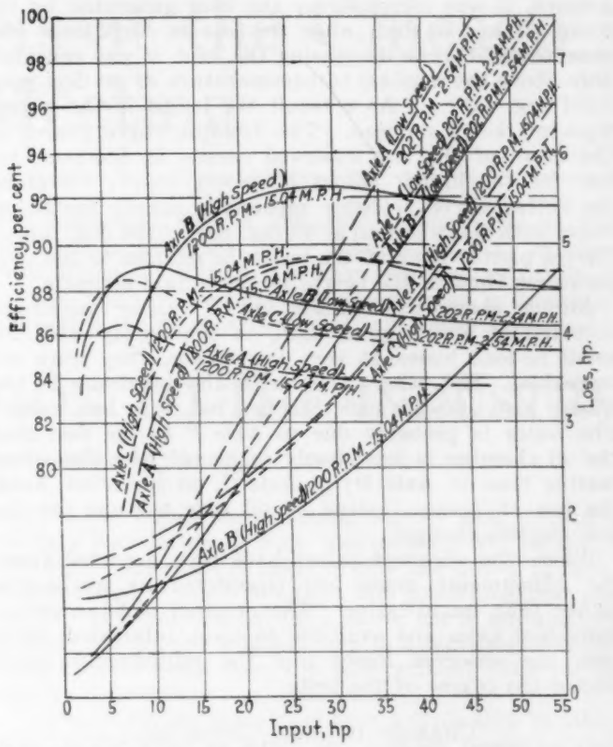

Efficiency, per cent
Loss, hp.
Input, hp
Axle B (High Speed) 1200 R.P.M.-15.04 M.P.H.
Axle A (Low Speed) 202 R.P.M.-2.54 M.P.H.
Axle C (High Speed) 1200 R.P.M.-15.04 M.P.H.
Axle A (High Speed) 1200 R.P.M.-15.04 M.P.H.
Axle B (High Speed) 1200 R.P.M.-15.04 M.P.H.

Fig. 36—Curves of the Losses and the Efficiencies of Three Worm-Drive Axles at the Highest and Lowest Speeds and an Oil Temperature of 40 Deg. Cent. (104 Deg. Fahr.)

presented. In some cases the spread between losses observed at the different temperatures is larger at the heavy than at the lighter loads. As stated earlier, the tests at each speed were made first at the lowest temperature used. As this was the first occasion that the axle was subjected to the high torque-values applying in the area of the increased spread, it is reasonable to suppose that the losses would decrease more in subsequent applications of the heavy torque, at higher temperatures, than appears justified by the reduction in the no-load losses resulting from the change in the temperature of the lubricant.

A few other cases at high power-input and low speed show a greater loss at 100 deg. cent. (212 deg. fahr.) than at lower temperature. This was at first accepted as resulting from a breakdown of the oil-film, as might be expected at very heavy pressures. Such a breakdown may possibly explain a part of these apparent inconsistencies; however, consideration of a number of these cases and the order in which the tests were made seems to indicate that the explanation given above holds good in these cases also.

A good demonstration of the magnitude of the losses caused by the oil in the wheels is found in a case where a change in these losses during a test seemed to warrant an adjustment.

In Fig. 35, four curves are shown for the losses in Axle *D* at 15 m.p.h. and 40 deg. cent. (104 deg. fahr.) oil temperature. The upper of the two curves drawn with long dashes shows the losses observed while the power input was being increased; the similar lower curve represents the readings with a decreasing load. The wide variation seen is due to a change in the temtemperature of the lubricant in the wheels; when the first observations were taken, this temperature was well below 40 deg. cent. (104 deg. fahr.). As the test pro-

gressed, it was increased by the heat generated by the prony brakes so that, when the loss at high loads was observed and while decreasing the load, it was considerably above the nominal test-temperature of 40 deg. cent. (104 deg. fahr.). As a result the losses in the wheels were markedly reduced. The full-line curve drawn as the mean of the two observed curves is, however, too low for the higher values of power input; therefore, the dotted curve probably represents closely the actual losses with the wheel oil at 40 deg. cent. (104 deg. fahr.). Curves plotted later of the losses in relation to the temperatures confirm the correction as a fair estimate.

Similar changes in the loss, but of smaller magnitude, occurred at lower speed until, in conformity with the small no-load losses at very low speeds, they were not traceable. The other axles with the lubricant in the wheels also showed such changes but to a less extent. The latter is probably due in Axle *F* to the fact that the oil chamber is less closely connected with the wheel casting than in Axle *D*; in Axle *G*, on the other hand, the use of grease instead of oil may account for the less marked changes.

Where the observed values have been departed from, the adjustments made are considered as qualitative rather than quantitative. The original plots, covering individual axles and available to those interested, show both the observed losses and the adjustments made during the course of the tests.

Changes in Axle Condition

The changes occurring in axle condition during the preliminary runs result in some reduction of the losses. In the worm type of axle, it was found that the reduction in loss might be 15 per cent or more for medium and higher loads at 8.5 m.p.h. In the gear drive, the reduction was found to be very much less. The change decreased as the preliminary tests progressed. The first application of a higher torque during the main tests at the lower speeds resulted in an apparent adjustment to this new load-condition and sometimes, also, in a slight further improvement at lighter loads. As a result, in some check-runs made after the efficiency tests at all speeds had been completed, a slightly lower loss than in the main test was observed for the higher speeds; for the lower speeds, the change was in most cases so small that it might be accounted for in other ways and in some instances there was a slight increase in the loss.

Selection of Axle *B*

The reasons for selecting Axle B to represent the worm type in the discussion of results will be clear from the following explanations. In the tests of Axles *A*, *B* and *C*, the variation in the worm-gear losses was so wide that no reliable comparison of the varying bearing-equipment could possibly be obtained. The changes taking place in the worm gears in these tests preclude the use of the same set for different bearing equipment. The variation as between these three axles as seen in Fig. 36 was so great that a number of worms and gears taken from Army stock were measured carefully and records of their operation taken on a Saurer gear-testing machine by the gage section of the Bureau. Two other sets later used in special tests in a Class-B axle were checked similarly. Variations in the measurements were found which, it seems, should be avoided to assure the most efficient worm-drives. Hardness tests were made on five worms used in the tests, as well as on three worm-gears; but these, as well as chemical analyses made of four gear-rings and wear tests made on an Amsler wear-and-friction testing-machine with discs cut from four of the gear rings, seem to indicate that these differences in the hardness, the composition and the wearing quality probably had less influence on the results than the accuracy of workmanship and adjustment. The last-named was made with far more care than could be expected in service, but it is not possible to assure an entirely equal adjustment in the several axles; and, if made without any load, the adjustment will be lost when power is applied and the contact between the worm and the gear will change. From the foregoing, it would seem that little reliance can be placed on any comparative efficiency tests of similar axles equipped with different bearings when subjected to loads of a relative magnitude similar to full-torque operation of these Class-B Army-axles.

The selection of Axle *B*, with its higher efficiency, to represent the worm-drive type, is made with a view to giving the type the benefit of any doubt. The ball bearings, although not used in the majority of these axles in service, are a second standard, and the worm and the gear are fully representative standard stock and possibly even better than the average.

AUTOMOBILE FATALITIES

THE number of automobiles in use in this country has increased five-fold since 1915, but the number of automobile fatalities has but little more than doubled. The education of the motorist and the pedestrian alike, the more stringent regulation of traffic and the institution of safety campaigns have helped to pull down the ratio of automobile fatalities to automobiles in use. Thus the death rate per 10,000 automobiles registered was 24.0 in 1915, 18.2 in 1917, 15.5 in 1918, 12.0 in 1920, 11.9 in 1921 and 11.6 in 1922. Despite these comforting indications the fact remains that automobile fatalities are increasing in actual number at the rate of 1000 a year.

The Interstate Commerce Commission's bulletins show the following automobile highway grade-crossing casualties for the years 1919, 1920 and 1921, based upon the reports made to the Commission by the railroads:

Year	Killed	Injured
1919	1,232	3,558
1920	1,273	3,977
1921	1,262	4,025

The analysis of 501 fatal accidents and 1000 non-fatal accidents that occurred in Massachusetts during 1922 showed the following:

Cause	Fatal	Non-Fatal
Motorist at Fault	347	826
Pedestrian at Fault	121	134
Motorcyclist at Fault	18	24
Others at Fault	35	38

Speed caused 158 of the fatal accidents and 361 of the non-fatal accidents.—National Bureau of Casualty and Surety Underwriters.

Discussion of Papers at the Chicago Service Meeting

THE discussion of the papers presented at the recent Chicago Service Meeting was submitted to the authors and the discussors for revision and further comment and is published herewith. For the convenience of the members, a brief abstract of each paper precedes the discussion, with a reference to the issue of THE JOURNAL in which the paper appeared, so that members who desire to refer to the complete text as originally printed and the illustrations that appeared in connection therewith can do so with a minimum amount of effort.

SERVICE AND ITS RELATION TO THE INDUSTRY

BY OTIS C. FUNDERBURK

AFTER outlining the ideas regarding the success of a service-station which the author had when he entered the service industry, such as a convenient location and consistent newspaper advertising, the 24-hr. service that his organization is prepared to furnish for Ford cars is described briefly. The methods employed in getting service work on Lincoln cars by the use of circular and personal letters are commented on briefly, it being pointed out that January and February are now two of the best months in the year as regards the amount of service work performed instead of being dull. The importance of a modern tool-equipment and the careful selection of the personnel for a service-station are mentioned, emphasis being laid upon the fact that in a service organization the men should have a fundamental education for their work.

A number of pieces of special equipment that have been purchased from outside manufacturers or developed by the author's own organization are illustrated and described. Among the latter are an inclined platform for raising the front end of the car when work has to be done on the engine from underneath, a special spark-synchronizing device and a rig for relining brakes. The importance of having a thoroughly competent floor-man to meet the customer and write the repair order is emphasized; and a brief description of the method of handling work in the shop is given together with an outline of the road-test that is made of all jobs that necessitate any change in the running-gear of the engine. The importance of delivering the car to the owner on time, clean and free from tool-marks is pointed out.

The flat-rate system of service charges receives consideration, the author being of the opinion that eventually practically all maintenance work will be handled on that basis. The way in which the flat rates charged by his service-station were arrived at are outlined briefly. An indication of the way in which cost data on an operation are secured and distributed among the various accounts completes the paper. [Printed in the March 1923, issue of THE JOURNAL.]

THE DISCUSSION

CHAIRMAN CLYDE JENNINGS:—Maintenance is the biggest part of the biggest industry in this Country. When gaged by the number of people employed and by the turnover, it is bigger than car building. The figures of 1922 show that about $2,000,000,000 worth of new cars was sold at retail and I believe that further investigation will show that the turnover on the maintenance, parts, labor and the like was about $5,000,000,000. Maintenance has been largely a correlation of the automotive industry, but things are changing rapidly and, instead of being a correlation, I think maintenance will be one of the main supports. It helps to give the dealer in cars a well-rounded business; it gives him something that goes ahead. It is not unusual for a dealer not to sell a car for a week, but anyone who has been in a service-station will agree that a week does not pass without calls for the service department.

Automotive engineers have been a trifle slow in taking this up, for what we might call a selfish reason on their part. If some of them had been looking toward their own financial benefit, they would have seen years ago that the big thing in the industry is service; that it was a growing business and that the designing of cars is not a growing business to the same extent. I have no wish to intimate that the designing of cars has reached a static condition, because I look for great and marked improvements in the details. An engineer is at home when he is considering details, but if he wants details he will get them in the service-station and details are important in the service-station just now. Details always are important until a craft or trade takes a set place. That is why such men as Don T. Hastings are devoting their attention to service; they are developing the details that are necessary for a better understanding of the question, the things that eventually will produce system in the maintenance business.

The question of flat rates is a question of undoubted importance. We do not need flat rates to produce a good job, but they help to get a good job because they drill the poor workman in the way he should go; but we do need them to sell maintenance, and anything that has the turnover that the maintenance business has must have a selling-point. This $2,000,000,000 worth of cars that I spoke of is sold by some 32,000 dealers. You can take your own estimate of the average number of salesmen employed by each dealer and multiply it by 32,000 to get an idea of the total number of automobile salesmen, but how many salesmen are selling the $5,000,000,000 worth of maintenance? People are buying maintenance because they have to, and they are getting the reaction of people who do things because they have to, who go to the few shops where the buying of maintenance is made a pleasant, understandable thing. When a customer comes in he must be greeted properly, he must be sold properly, he must be told that he must leave the car and the salesman must return the car to him in good condition.

After the maintenance work has been done, it must be serviced, and I think that is the difference between main-

tenance and service. When you buy an automobile, you deserve service; you deserve to be greeted properly, to have an attractive place to go to buy that car and all the things that go with merchandising, such as the 90-day guarantee and the readjusting of the valves. Many of those things are service but, after service has been given, then what have you? If you sell a customer a $225 job of maintenance, then you must service that maintenance; if you reground the cylinders and put in new pistons, you owe him the same service on the maintenance job that you gave him on the new car. If a readjustment must be made to make the job a good one, you owe it to him; that is service. But if he has bought the cylinder-regrinding job and you are servicing that, you do not owe him such maintenance as relining the brakes. We need to sell the parts and we need to service them.

C. F. CLARKSON:—The flat-rate system probably will be satisfactory for much the same reason that the tariff on imports is considered satisfactory, if there is definite knowledge as to what it is and will be over a reasonable length of time, and within liberal limits as to figures.

The word "service" is used, of course, to indicate a great number of things. Many of the meanings attributed to it are vague. Its general meaning is very broad; there is scarcely a word of broader import in our language. It suggests matters of an ill-defined character. This is undoubtedly a main reason it has lacked specificness and concreteness in our field.

The saying that the road to greatness is the road of service is about as old as the hills; and it is as true and as enduring as the hills. It is time that we made a more thorough application of the principle. It is obvious that the prestige and the lasting success of automotive companies, particularly those engaged in the passenger-car and the motor-truck fields, depend upon the satisfaction their products render. Service is an integral part of their activities that cannot be long ignored. To maintain a position in the highly reputable and prosperous way that it should be maintained, and will be maintained by those who shall survive through the coming years, motor-vehicle builders and dealers must meet in a fair and square manner their responsibilities, which are inextricably linked with the needs of their car-using customers. They must give to receive. That axiom is pertinent with peculiar force in our industry.

There is a clearly defined indication that our political and social problems cannot be solved by any methods other than those that have been followed in recent general scientific and engineering progress; and that they will be solved by those modern effective methods. Surely, one of the first thorough-going reductions to practise in this respect should be in the servicing of the millions of motor-cars now in operation, not to speak of the many millions more to come. What has been said here today by very well qualified speakers defines pretty plainly just what steps should be taken.

The securing of practical success must be based on an ideal. Frequently, stressing the ideal arouses the thought of impractical notions, but a proper ideal is essential and usually is the governing factor in the success of a business. Having the ideal, the procedure of how it shall be made concrete in practice must be settled. The ideal, or the right idea, which is another name for the same thing, must be physically embodied by action, which alone will show definitely what the ideal really is and, in turn, how that which has previously been set up should be modified according to circumstances. The essential thing is that the vehicle vendors and the others concerned desire to do, and do, what their instinct tells them is the right thing to do; and that it shall be said that what they do is done. The adequate working of their spiritual "self-starters" results in mutual good for the buyer and the seller. The longer the comprehensive solving of the service problem is deferred, the more arduous it will be to accomplish. The statement that we reap what we sow is scientifically correct.

The securing of big results involves conquering great difficulties. The establishing as fully as possible of desirable conditions in the very complex and widely scattered field of automobile service requires long and thorough study by the best brains of the industry. All the phases of the unbeatable law of compensation are latently present. The matter should be carried forward with dispatch, and with all the solemnity of a pledge for the good of the industry and the public. The typical respective responsibilities should be clarified and met, not blinking that prime element, human nature. We should be as little lacking as possible in knowledge of the vital features of satisfactory service. The time to take intelligent action is in advance of the coming of obstacles that may be nearly insurmountable. Let us do the best work of which we are capable on the great service problems that are before us.

DON T. HASTINGS:—With regard to special equipment, we have done very much as Mr. Funderburk has done. The tool I described for expanding the tubes to take out the rattle in the steering-gear cost us $15 to $20 at first; now it costs about $2.50. Another tool is a piston-position indicator; it works in through the spark-plug hole and it is not necessary to take off the head to determine where the piston is. It is a lever-multiplying device that is of great assistance in setting the timing. We have a front-wheel lining-device different from the one that has been described; to my mind, it is somewhat simpler to use. It is a bar having two levers, one mounted on each end. The levers fit against the felloe of the wheel and each carries a pointer that registers on a graduated bar; in about 15 sec., one can determine whether the wheels are properly lined-up.

CHAIRMAN JENNINGS:—How many think in the terms of the man who does most of the work, not those of the man who runs the shop, who can afford to have an engineer at the head of it, but the man who must be content with a mechanic, and with certain limitations in interpreting these ideas to his own organization? It is always well to apply ideas to a small organization. Whenever we describe a high-class shop that has all this equipment, we try to tell later what it means to the little fellow; it means very much to him. Consider how many cars are serviced by small stations. One-third of the cars are on the farm; naturally, they cannot go to Mr. Funderburk's station, so they go to a nearby station.

J. W. LORD:—In connection with the expansion tool Mr. Hastings described, it was developed in a service-station, was taken up by the factory and then was made for about one-tenth the cost of the first one. I think that the development of a tool in a service-station, it being taken up by the factory and then sent out, is something that the factories should note and consider very seriously; that much better action will result than if the factory should try to develop it.

CHAIRMAN JENNINGS:—In other words, the man in the service-station gets the actual contact with the vehicle as it is.

MR. LORD:—I think the factory service-department broadcasts tools that it should not broadcast; it would be better if its representative went into the service field to find out what the various tools are that have been de-

veloped for a particular job, because very often some better tools can be developed.

B. M. IKERT:—In an instance that I know of personally, the cooperation of a manufacturer's equipment is helping greatly in the field of service. Men who work on a certain very popular car are under the impression that the work is fairly accurate on the block; they turn the block upside down, then hook up the burning-in machine. We checked a number of blocks and found a difference of 1/16 in.; and that makes a big difference. One company has brought out a burning-in machine with which it locates from the bottom of the block; the block is put right-side-up and is always properly lined-up. Few mechanics can appreciate a variation in the height of a block. This is a case where the manufacturers have checked-up and are really helping in the field of service.

Mr. Hastings spoke about attaching a postal card to a car and asking the owner whether the work had been satisfactorily done. With the facilities that most men have who do that kind of work, I should expect the customer to take it for granted that I was sure the job was right and did not need to ask his opinion. I may be wrong. I never ran a service-station; but if I had a properly tooled shop, if my men were right and I had an inspector on the job, I should feel entirely confident that the jobs had been done right. Mr. Hastings mentioned a mechanic who left the cotterpins out of the connecting rods. Has he a man who inspects those jobs before they are put together? In one service-station in St. Louis, before a mechanic puts a rear axle or a crankcase together, an inspector looks over every point and passes on it before the man can complete the job.

MR. HASTINGS:—Regarding the cotterpins, the oversight was detected before the car was sent out. The inspector passes on the work before the workmen close up any job.

MR. IKERT:—We draw too sharp a line of demarkation between service and sales; they really are the same thing. The days are past when we could go into a salesroom and then out into a dirty repair-shop through a cubby-hole in the wall. I was in a salesroom recently and was led gradually through to the shop; then I thought we were still in the salesroom. That shows how close sales and service are. We are making too many bones about some service matters; many dealers in this country have fine service-stations and, although they have many problems, they are just everyday problems. Customers want the same kind of service they get in any other line of business. As I see it, selling maintenance is not more complicated than selling anything else; the dealers that I have talked with in this country who are using the flat-rate system of selling maintenance have told me they never would go back to any other system.

MR. HASTINGS:—With regard to asking an owner whether the work is satisfactory, we find that many times the owner is not satisfied for a variety of reasons. Rather than let it prey on his mind and have him go around talking to his friends instead of telling us about it, we try to find out as soon as possible whether there is a sore spot. If we can reach him the next day, we almost always can clear away that impression, but if the matter is allowed to run for a week, it becomes much worse than it was when the thing happened; and, in the course of a month, we become the most horrible example of maintenance station it is possible to conceive. Frequently, it is some little five-cent thing that really would not have amounted to anything if we had been able to reach him while the thing was fresh. We think it is important enough to follow up.

MR. IKERT:—Do you have in your station a man who represents the customer? I know of a St. Louis company that has a man who looks over the car from stem to stern before it goes out. When he passes on the work, the company feels absolutely sure that the car can be turned over to the customer.

MR. HASTINGS:—That is not delegated to one man alone with us. Our chief inspector is one of the absolutely thorough workmen that you do not find very often; he makes an ideal inspector and at the same time has a way that enables him to get along with the men in the shop. The other men who represent the customer are our service salesmen, who are much interested in avoiding "comebacks" because they must bear the brunt of them. So, we have two groups of men who represent the customer.

As to linking sales and service, it is not service exactly, but we have taken a step this year in the sales department that I think will accomplish that result. We have divided our sales organization into eight teams; each team is under a division sales-manager. Everybody in the organization, except Mr. Williams and myself, has enlisted on one of the teams as a part-time salesman. We pay part-time salesmen 5 per cent on sales and the division manager gets 2½ per cent on any sales that may be made by a member of his team. In other words, we are offering 7½ per cent commission to be paid on sales, so that the service organization and the sales department are linked very closely. So far, the plan seems to be working out very happily. The salesmen, the division managers and the general sales-manager all are getting to know the men in the service organization better. I spend all my spare time preaching the gospel of good service and telling the salesmen what we are trying to do. This seems to be one way to get the close cooperation that we must have if we are to succeed.

L. C. VOYLES:—A point that Mr. Ikert mentioned and that Mr. Hastings has answered, is the matter of being too sure. That is the trouble now; we have been sure, but the other fellow has been doubtful; and we all must admit that one of the problems that confronts the automobile industry today is the feeling on the part of the ultimate consumer. He does not feel that we have the good service that we are talking about and are trying to improve and to bring about. He has the idea that all service-stations are more or less "punk," some more punk than others; and that is a matter of fact. You may continue feeling sure and take a cock-sure attitude with him if you wish, but you must do something to make him appreciate that point, to get him to look at it from your viewpoint.

The plan Mr. Hastings is following is an excellent one; it is something that the owner is not accustomed to and, consequently, will talk about. It would help if we could get him to follow the sign that we see in various places, "If we please you, tell others; if we do not please you, tell us." If everybody would follow that rule, all would be well and good; but it is human nature not to follow it. We damn somebody because something was not done to suit us; not one per cent of us ever go back and tell the fellow who could and really would like to correct it. We do not tell him, we tell everybody else, and some one who does not know the actual facts in the case thinks an awful condition exists. It is this condition that we must break down; we must do something extraordinary to break it down. It strikes

me that Mr. Hastings' plan is entirely feasible and one that could be recommended to all the service-stations in the country.

T. C. PLUMRIDGE:—There is another point in asking the customer whether he is satisfied. A customer brings his car in, wants certain work done and it is done, but something else is discovered in the meantime that should be done. The car goes out; the customer may not know of the extra work that should have been done and, after the car begins to run badly again, he brings it in. If the customer had been asked immediately whether he were satisfied with the work, the service-man would have a "comeback" on him and could say that it was not the service work that was wrong.

MAINTENANCE EFFECTS OF AUTOMOTIVE ELECTRICAL-EQUIPMENT STANDARDIZATION

BY A. H. PACKER

THE author outlines past conditions that led to a diversity of design for similar parts, such as tires and rims, as being analagous to the causes of present variations in automatic electrical equipment intended for identical purposes, and gives specific instances in which such variation has resulted in excessive expense and delay.

Constructive suggestions are made for improvement in regard to reducing the number of types of equipment and standardization of the remaining types, more especially with regard to generators, as a means of making possible better service-station efficiency and a reduction of the investment now necessary because of the carrying of an excessive number of parts in stock. Standardization problems are stated and commented upon, and the advantages of a reasonable degree of standardization for electrical equipment are set forth. [Printed in the March, 1923, issue of THE JOURNAL.]

THE DISCUSSION

CHAIRMAN CLYDE JENNINGS:—There has been a disposition to say that electrical service cannot be mentioned with mechanical service, that it has to be departmentized; but the point is that no car is better than the service behind it. We all admit that, but we all do not admit yet that no car is better than the service behind it regardless of where that service is obtained. Another point worth considering is that if you do not include electrical maintenance in the service-station, you will tell Mr. Car Owner to go two blocks to the left and four to the right to an electrical service-station to get the car fixed. What will happen next? Will you tell him to go down another street to get the axle fixed? I believe it has been said that the nearest "own-made" car patronizes 209 parts-makers. Would you have people shopping round for parts-makers to fix a particular part, the drag-link or the axle or the engine or the generator?

J. W. LORD:—I think standardization of electrical equipment is important; but, at the same time, suppose we did get down to five armatures; these have a different relation, to my mind, from the various makes of tire. If a man makes B equipment with a very fine armature and the machine happens to go wrong, so that it is necessary to replace the armature with an A armature, a B name is still on that machine. If I were a B manufacturer I should not care to have an A armature put into that machine because my name would be damaged if that A armature that was not as good as mine went wrong.

From a service standpoint, I think that, so far as possible, electrical service should be given by the distributor of the car. I have had experience in buying a car and taking it back because the electrical equipment would not operate. I was told "We do not take care of that; you will have to take your car down to such-and-such electrical station." I took it there, they spent some time on it, and the next night I was stuck again without lights. That happened three or four times, and it kept me bouncing back and forth between the people who sold the car and the people who were supposed to give the electrical service. Finally, I told the car dealer that he must fix the car or take it back; and he had it fixed. I think this business of being sent down the street to get this or that done is wrong.

CHAIRMAN JENNINGS:—As I understand it, the point about the armatures was that if a dealer had only five he could be sure to have a B armature in stock to replace the B armature and an A armature in stock to replace the A armature; but he has not a chance in the world of having 160 armatures in stock.

A. H. PACKER:—If you have an electrical unit of a certain make, the maker would prefer that you have an armature of the same make, but at present he has nothing to say about it. In the country, they rewind any armature and after it has been rewound, nothing that was in it originally is left except the iron. The winding is the most valuable part of the armature; that is, the way it is put on and the treatment that is given to it at the factory. The process of impregnating really makes a good armature.

T. C. PLUMRIDGE:—There is some trouble in that engineers are always changing the types of armature or the types of electrical equipment that they put in. I have one of these big sets of blueprints of electrical work, and sometimes I get inquiries about certain electrical parts. As many as three different equipments have been put into one car within a year. I think that engineers should standardize the equipment and not make three changes in one year.

H. R. COBLEIGH:—I know "you can lead a horse to water but you cannot make him drink." The Society has been making standards for a long time, but the standards are not used as much as they should be. The Society has the agency to help sell its standards; namely, a simplified practice committee, and the National Automobile Chamber of Commerce has a corresponding committee working closely with it. We have high hopes that we may be able to induce the "horse to drink" through the activities of this joint committee.

Another way of getting the standards adopted is somewhat akin to that which is being tried to solve the "pirate" parts problem, educating the public. I wonder if we cannot sell the public the advantages and create such a demand for standardized equipment that the industry will have to heed it. If the dealers find out that the customer says, "I want the car that has standardized equipment so that I can get an armature anywhere I happen to be," you will find that the dealer will tell

the manufacturer, "We must have this standard equipment because it is difficult to sell cars without it." The manufacturer then will get busy.

I think Mr. Lord and Mr. Packer were talking about two different kinds of A and B armatures. Mr. Packer was referring to five different types of armature for one make, and all makes using the same five types. Mr. Lord talked as if A and B were different makes, as if he had a Westinghouse generator and, when the armature burnedout, he were given a Gray & Davis. The electrical-equipment manufacturer may object to having some other make of armature put in his generator, but the thing we must keep in mind is what we are preaching all the time in connection with our service work, which is that the car-owner is the fellow to be considered. Let us stop worrying about what the manufacturer likes and does not like and ask ourselves what the owner prefers.

B. M. IKERT:—We have assumed that service and maintenance always will be part of the dealer's business. We have said in times past that perhaps a large part of the work will be farmed-out; perhaps, one big central shop will do nothing but grind cylinders. Are we to farm-out the electrical work the same way? In an electrical shop I can see the advantage of standardizing armatures in that so large a stock would not have to be carried. Not long ago I was impressed by the practice of a company that had an electrical service-station. I said, "I am surprised that you do your own electrical work here." They replied, "Inasmuch as we have sold these cars to the owners we feel that we are responsible to them and we intend to have everything we can do done right under this roof; we do our own electrical work, so that when a man comes in we need not say, 'We do not make that generator, you must go down the street to a man who will fix you up on that starter.' We can take care of him here." It seems to me it is largely a matter of whether we intend to have outside shops specializing in this and that or intend to make it a part of the dealer's business.

MR. LORD:—I am in full sympathy with the idea of the dealer's doing his own electrical work so far as possible. It is my experience that, if something goes wrong with the ignition or the lighting or the starting, the chances are that the man will blame the car, irrespective of what the equipment is, and that the average electrical repair-shop will take twice as long as we take to handle the job. I think we can exert more pressure than the average individual owner. Of course, I am located in New York City and my case is different from that in some isolated community. There should not be one rule for both the big city and the small town. I should like to go much further in the matter of electrical repairs than we have gone. I believe we ought to buy the parts direct and get them direct and not be hampered by electric service organizations, because a job can be done twice as quickly without that interference. If you can finish a job in 2 hr. or ½ hr., it is better than taking the generator out, sending it out, getting it repaired, getting it back the next day and starting the customer on his way in 24 hr. An inflexible policy does not permit this today.

CHAIRMAN JENNINGS:—Some time ago I asked about 35 men, "What kind of car have you? What kind of engine is there in it?" and 35 replied that their engine was the same make as that of the car. They were not careless people; they were business men. More than half of them told me that the electrical system was the same make as that of the car. These men are honest and intelligent and are looking to the maker whose name is on the front of the car to take care of it. The fact that they did not know that the electrical systems were different does not alter the case. The cars that will survive are those into which the people behind them have put honesty of purpose and some intelligence; nothing else will avail. They have produced a very complicated piece of machinery and must do their best to keep it in operation.

As a matter of fact, we have not accomplished anything when we have built an automobile; we have not accomplished anything when we have built a highway. But when we have a highway and an automobile, we have two means to an end, the end being transportation. We must get the attitude that we all are dealing in transportation and transportation only, not in automobiles; when we get that attitude with regard to maintenance, we shall advance; the factories that maintain that attitude are the factories that will succeed. We have two definite propositions. Mr. Lord has pointed out one of them in the big centers of population; the second is that of the small station, which must have an all-round mechanic to keep it going.

THE DEVELOPMENT OF A MODERN SERVICE-SYSTEM

BY DON T. HASTINGS

THE author states that the word "service" has been and still is the most abused word in the automobile language and enumerates some of the causes of poor service. Good service is then considered as constituting a sales asset. The new attitude toward service is described and the progress of the building-up of a combined flat-rate and piece-work system is outlined.

The flat-rate and the piece-work features are analyzed, inclusive of the methods applied to each and comments upon the results obtained. Records form an all-important part, and these are kept on special forms that are illustrated; the method of their utilization is given in detail. The duties of the different members of the service personnel are specified, and it is shown how the different factors are made to combine and produce service that satisfies the car-owner. [Printed in the February, 1923, issue of THE JOURNAL.]

THE DISCUSSION

J. F. PAGE:—Will Mr. Hastings tell us how he arrived at the time limits on which he established the piece rates?

DON T. HASTINGS:—It is just a matter of getting the actual time of the various operations through the time-keeping system in the shop. We had difficulty with some of the men, who tried to complicate the task. They would work, say ½ hr. at one operation and 1 hr. on the next, and then would report 1¼ hr. on the first one and 15 min. on the second. There always will be some persons in an organization who are not willing to cooperate, and afraid you will take something away from them. But

it did not take long to find out what men were making the trouble, and conditions either became so unpleasant for them, with a foreman watching them all the time, that they quit, or else we actually asked them to leave the organization, so that we soon obviated that trouble. Then, as the time records began to come in, we put a man to work posting the actual time of each operation. We had a book with a sheet for each operation. On each sheet we listed the date, the repair-order number, the time and the name of the workman so that, after a short time, we were able to go through them and strike an average for each operation and compare the various times with the average. We found some men, for instance, who would report 5 min. for changing a radiator, which obviously was impossible; on the other hand, once in a while they would take 5 hr. to change a radiator, which was just as unreasonable. We had to go through a large amount of detail work in checking these excessively long or short times, eliminating them and finding the reasons. Sometimes it was only a mistake in posting; they would get the wrong operation number, so that much detail work was involved in separating the times that obviously were wrong. The shop foreman and I had pretty fair ideas of the proper time for a given operation. We could guess it within from 25 to 50 per cent, at least. We did not use a stop-watch; we depended on the honesty of the men.

A MEMBER:—How do you establish the rate of pay of the mechanic for an operation?

MR. HASTINGS:—That was based entirely on the average time computed from the time-study. Then we figured that the men ought to make about 25 per cent more in a day than their hourly rate called for. In most cases, the first estimates have been reduced. In a few cases we found we had set the time too low, although, as the men got used to the work, they speeded-up.

A MEMBER:—Did you rate them all equally as mechanics, or have a different rate for helpers?

MR. HASTINGS:—A man who scrapes bearings is paid a certain amount, and a man who greases a car is paid a certain amount. The foreman has to use judgment in assigning the work to the men. He would not put a helper on a bearing-scraping job; on the other hand, generally, he would not ask a man to put on a bumper if he is a bearing-scraper. He must use judgment, but for a given operation there is a standard rate of pay.

A MEMBER:—Then if you do not have suitable work for the mechanics, you pay for the idle hours?

MR. HASTINGS:—That is our loss. We pay them at the straight-time rate. This is a point that we have not taken care of yet. We intend to establish a lower rate for lost time than the straight-time rate, but the psychological conditions have not yet been right for putting that into effect. It has been done in other places and I am sure that it can be done satisfactorily. We find that probably 75 to 80 per cent of the work comes in between 8:30 and 9:30 a. m. A few jobs, of course, stay in the shop over night, but they are relatively few. Most of the jobs are in the 3-hr. class and under, so that probably one-half the men have nothing to do for the first hour. The result is that we are not insistent that the men be there at 8 o'clock, the regular starting time. If there is a particularly crowded condition, the foreman says to the men, "You be here tomorrow morning at eight"; but they drift in about eight-thirty, so it is all right.

L. C. GREENAMYER:—What percentage of lost time do you figure as efficient service?

MR. HASTINGS:—I cannot give the percentage offhand. Our shop payroll is about $4,000 per month at present; the actual lost time last month cost $250. That is as near as I can give the figures.

MR. GREENAMYER:—I have had the same difficulty that you and every service manager have had regarding the delivering of cars to customers in a satisfactory condition. I found that I could not leave it to the mechanics to cover the upholstery. In my plant, a closed car or one having delicate upholstery is sent immediately to the upholstering department and covers are tacked on that cover the upholstery. These are taken care of in one department and are laundered whenever they show signs of being soiled. I have found that this has saved more money than any other thing.

MR. HASTINGS:—We leave it to the shop foreman to see that the upholstery is covered. We have no upholstering department, but we launder the covers as soon as they become soiled; the foreman pays particular attention to see that the covers are put on before the men start working.

MR. GREENAMYER:—Do you have covers made to fit each model?

MR. HASTINGS:—We use ordinary sheeting.

MR. GREENAMYER:—I find that heavy denim gives the best satisfaction.

J. W. LORD:—Do you give additional compensation for work over the amount on which the flat rate is based?

MR. HASTINGS:—No, except in cases where we shift a man from the contract rate to straight time.

MR. LORD:—It should be of interest to the foreman to see that the men make as much as possible.

MR. HASTINGS:—They do that by speeding-up the straigth-time work to get back on the contract operations that pay the higher rate.

H. R. COBLEIGH:—At a meeting of the Automotive Electric Service Association, while flat-rate and piece-work were being discussed, the question was raised of overcoming the difficulty with the men when it becomes necessary to lower a piece-work price previously established. Mr. Hastings has said that if he were starting a service-station today he would install piece-work at once and make the necessary changes afterward. How would he make changes without creating sore-heads among the men?

MR. HASTINGS:—We did have some sore-heads. In fact, about a third of our force quit. We started the piece-work system on the first day of August and, the evening before, we had a caterer bring in a nice supper. We cleaned out the shop, and set tables there for everybody in the service organization and the parts department. We had dinner, passed out cigars and told a few stories; then I told the men just what we intended to do. I painted the picture as reasonably as possible, tried to show them that it was to their advantage to work under this system and told them of other shops where it had been instituted. We did one other thing at the same time that was calculated to help over the rough spots; we put in group insurance throughout the entire organization. The expense is about $1 per month per individual in the organization. There are two classes, the executives who have a certain amount of life insurance to start with, $2,500, I believe, and the men in the shop who start at $1,000; and these amounts increase with the length of service until the limits are doubled.

The men did not say very much after I had finished talking, although I encouraged them to talk; some asked questions, but the meeting practically was over when I finished speaking. Then I left them to talk things over. We had about 36 men at that time. Within the next week about one-third of them either quit or grew so ob-

streperous in reporting inaccurate time that we asked them to leave. After we got rid of the trouble-makers, the remainder, one-half of whom had been with us for more than a year and some who had worked for many years with various distributors in Detroit, helped us and worked with us. They are thoroughly convinced, I think, that we are trying to be absolutely fair to them; and this is a mental condition that must be secured in a shop before a system of this kind can be run successfully. You must have the men pulling with you, and that means you must be absolutely fair; you must go beyond this fair point sometimes in getting the men's cooperation.

MR. COBLEIGH:—That covers the starting of the system; there always is difficulty in installing a system, but after it has been installed, there is still difficulty in correcting mistakes in the rates that have been established.

MR. HASTINGS:—We have not found it so. The men are making about 25 per cent more than under the old rates. When we put through the last changes in rates, it happened that the number of rates raised equaled those that were lowered, and that was emphasized by the foreman. We found that we had gone too far in cutting the price of certain operations. Where we had gone too far, there was only one thing to do, and that was to raise the price again to the point where the men could make a proper amount of money. It is a matter entirely of having the men believe that they are treated fairly.

MR. COBLEIGH:—Do you make the changes in rates effective at once or at a future date?

MR. HASTINGS:—Whenever we see fit. We post a notice on the board, "Beginning this morning, such-and-such rates are changed." We simply have gone ahead and made changes; there has not been any trouble.

EDGAR GARDNER:—Have you ever considered setting up a reserve so that the non-productive labor would participate in the saving?

MR. HASTINGS:—We studied that carefully for about 10 months but discarded it for two reasons; because of its unwieldiness and second, the difficulties in handling what is called the maximum-estimate system, which is based on the condition of cars when they come in for service. One fellow takes as good care of his car as he would of his piano; his car is in fine condition. The time required on that car is the minimum. Another fellow abuses his car, never greases it and never washes it. The tire required for a given operation on the two cars is very different. The maximum-estimate system is based on giving the careful owner the advantage. That is where the trouble occurs; when you tell the other fellow he has not taken care of his car, you antagonize him; he says, "I grease my car every other day and wash it every night," and so on. He is lying; there is no doubt about it, but you cannot tell him that he is without antagonizing him, and then you have more trouble than if you had made it a flat-rate proposition.

We take care of the participation of non-productive labor in a different way. We give bonuses at the end of the year to our non-productive men. It is difficult to arrive at a rational basis for a bonus for the non-productive group; at least, we have not been able to devise anything yet that is rational, so we have arbitrarily given each man a check of whatever size we deemed proper at Christmas.

MR. GARDNER:—Do you believe that the system really enables a man to capitalize his ability?

MR. HASTINGS:—There is no doubt about it, so far as our experience goes. We have had no trouble in getting good mechanics; they are attracted to the shop because of the report of high wages and good working conditions.

MR. GARDNER:—Have you ever considered paying a bonus on a completed job, based on a percentage of the number of hours' work and the rate of pay? If a job came into your shop that involved possibly three or four different kinds of work, such as transmission work, engine work and the like, have you considered paying a bonus on that job as a completed job as compared with the individual operation?

MR. HASTINGS:—No; we talked about it but dismissed it because of too great complication in bookkeeping. A man may be good with a wrench, a screw-driver and a pair of pliers, yet when talking percentage or bonus, he is lost. It is essential that the men understand clearly the basis on which they are paid.

MR. GARDNER:—Have you ever found that when two men are working on a car and one operation overlaps the other a tendency exists for one man to antagonize the other, to get the advantage of having completed his job first?

MR. HASTINGS:—We have had practically no trouble of that kind since we got rid of the few men who were trouble-makers at the start.

MR. GARDNER:—What is the minimum efficiency percentage of your present plan? For instance, you have one man 125-per cent efficient; he earns 25 per cent more than he would earn on straight time.

MR. HASTINGS:—I cannot say, without referring to the figures in the detailed analysis.

MR. GARDNER:—Do you set a maximum?

MR. HASTINGS:—No, that is left to the foreman's judgment. He sizes-up the men; if they do not come up to the standard, he gets rid of them and gets someone else.

MR. GARDNER:—Do you set a maximum amount that a man can earn?

MR. HASTINGS:—No. One man, whom we had to get rid of finally, was the fastest man with tools that I ever have seen or ever expect to see. In one particular job he changed a clutch-release bearing in about 2 hr. This involved pulling out the floor-boards, taking off the transmission, dismounting the clutch, taking out the bearing, putting it back, assembling the clutch to the transmission and putting the transmission and the floor-boards back. The average time on that job is about 6 hr. I probably would take all day to do it, and then would not finish it. But he became careless; he left a couple of cotter-pins out of connecting-rod bolts one day. After a few things like that, and when we found we could not cure him, we had to get rid of him.

T. C. PLUMRIDGE:—How do you regulate the amount of straight time that the men work?

MR. HASTINGS:—That is the duty of the service salesmen. We try, so far as possible, to put everything on contract. There are some wreck jobs on which it is impossible to establish a flat rate, because we cannot determine until we get inside what the job will amount to. We sometimes guess and quote a price, but that price always includes a large margin because of the uncertainty; probably 25 per cent more than the bill would have been on a straight-time basis.

MR. PLUMRIDGE:—When several men are working in a shop, how do you regulate the straight time? You cannot give one man more straight time than another.

MR. HASTINGS:—The foreman takes care of that. He assigns jobs to the men and it is his duty to rotate the straight time and piece-work so that all the men will have equal chances.

MR. PLUMRIDGE:—You have the chance of a foreman's giving the preference to certain men.

MR. HASTINGS:—Yes; but our foreman does not show

any preference. We have done considerable educational work with our men. We establish certain fundamentals and we talk them day in and day out with little sidelights on them on particular occasions that come up, until our whole crew, I think, thoroughly believes in those fundamentals and is trying to live up to them. If we find a man that will not fall into line, we simply get rid of him. We try the educational method first, and if it does not succeed, we get someone else. It is the business of the service manager or the foreman to pick out the men and educate them.

MR. GARDNER:—An owner will pay for the work, regardless of whether it is done in the minimum or in the maximum time. To a certain extent you are taxing the man that keeps his car in good condition and giving the man who does not take care of his car the benefit. You fix the minimum rate that a man should earn and a maximum rate; you arbitrarily adjust the rates so that the men can earn about so much money; you mention 25 per cent. It looks to me as if you have figured that these fellows can earn 25 per cent and that this amount is about what you intend to give them.

MR. HASTINGS:—That is about the way it works out. They can earn about 25 per cent more than on the average day's work or the hourly rate in Detroit. We are competing in the labor market with persons who pay about 50, 60 and, in some cases, 75 cents per hr. for labor and we make it possible for a man to earn approximately 25 per cent more than at the established hourly rate in Detroit.

MR. GARDNER:—You only come about half-way with the proposition on both those points. It is a compromise proposition.

MR. HASTINGS:—That is true. It would be very satisfactory if a feasible system could be worked out to give the careful owner the benefit of the saving, but we find that the average owner is not interested so much in whether the hourly rate is 75 or 95 cents for a particular job as he is in knowing before the work is started what the total cost will be. Further, we consider this method of charging the owner compares very favorably with the charges for insurance or with street-car fares.

MR. LORD:—Do you give the owner any indication of what the material charge will be?

MR. HASTINGS:—When it is likely that much material will be involved, we tell him that if certain parts are required it will be a certain amount per piece; but, in most cases, we cannot tell.

A. B. CHAMBERS:—You spoke of having a very fast man in your service department who did a 6-hr. job in 2 hr. Did you ever have a man bring in a car and, when he found it ready sooner than he expected because the speed of that particular workman was greater than that of the average mechanic, call you a robber for charging $3 to $4 per hr.?

MR. HASTINGS:—That is easily taken care of, if you watch it. We simply do not deliver the car in that length of time. We have had several of those cases but, at most, they are rare.

MR. GARDNER:—What percentage of the cars that come in have had excellent care?

MR. HASTINGS:—I cannot say as to that.

MR. GARDNER:—You really do not know then exactly how the flat-rate is affecting the owner, whether the man who keeps a car in poor condition is getting the advantage.

MR. HASTINGS:—To my mind, that is more or less an academic proposition. The average time as compared with the minimum and maximum times will not be 25 per cent off from either, except in extreme cases. Suppose a man averages 2 hr. A man who keeps his car in excellent condition possibly could get that job done in 1½ or 1¾ hr.; it might take the man on the other side of the fence 2½ hr. The actual difference in cost is more than made up by the speeding-up all through the organization. Suppose these two jobs were put on a straight-time basis, you would find that, instead of the 1½ hr. that the one job would take under our present system, it would take a full 2 hr. on the straight-time basis; and the job that would take 2½ hr. under our system would probably take 3½ hr. on the straight-time basis. They both win, but the fellow that does not take such good care of his car wins a little more than the other fellow, but they are both ahead of the game, because all the work is speeded-up. Fairness with the owner is a fundamental requisite of all service, if it is good service. We do not tell the owner that the job will take 1½ hr. and then do it in ½ hr.; we do not talk time to him at all; we tell him that a certain job will cost him $1.50 or whatever it may be, and he agrees that that is a fair charge for the work when he signs the order. If there is an impression in his mind that it is not fair, he does not have to sign the order or leave the work with us. It is not like charging him two or three times what the work is worth after it has been done; the price is agreed upon beforehand; if he does not like it, he need not give the order.

A MEMBER:—If a man felt that he were being "gypped" by the flat-rate system, why would it not be right to work on his car by the day and charge accordingly? He would find out in the long run that he was paying more than it would cost the other way.

MR. HASTINGS:—It would be right. We do it on request, but it is seldom requested.

MR. COBLEIGH:—It makes no difference to the mechanic how the car got into a certain condition. The reward of the careful driver is that he does not get into the shop for repairs nearly so soon nor so often as the careless driver. When bearings are worn-out, it is immaterial how they were worn-out; they must be replaced. The old illustration that a bald-headed man pays as much for a hair cut as the man with bushy hair is another answer. I do not believe Mr. Gardner knows how many hours it took to make the suit of clothes he is wearing, and I do not think he cares. The flat-rate is better for the cautious owner as well as the careless owner because the average that both pay on the flat-rate plan always proves to be less than even the careful fellow has to pay on the time-and-material basis.

MR. PLUMRIDGE:—What did Mr. Hastings do in the way of educating his men, in giving them the easiest way to their work, and so on?

MR. HASTINGS:—A blueprint sheet covering each operation was used. We explained to the men in detail what we were trying to do and the inspectors, shop foremen, service manager and myself all have collaborated in getting into the instructions the best methods and the best routine or sequence of operations to do the work properly and with the least effort. When a man, for instance, develops a certain tool, he is rather proud of it, and the foreman soon knows about it. If it is worthwhile, we have one or more of them made and put into the tool crib for the men to draw out as they need them for that operation. I think the whole answer lies in getting the confidence of the men. If the men believe that you think of their interests and want them to succeed and make more money, and you enable them to advance their positions as the opportunities occur, you will

find that they will be more than willing to cooperate; at least, we have found it so. The man who now is our shop foreman came into the organization as a mechanic. He worked for 6 to 8 months as an ordinary mechanic with no promises whatever in the way of preferment before we boosted him into his present job. The two men who act as inspectors at present started in as ordinary mechanics.

MR. PLUMRIDGE:—Do you supply instruction-books to enable the men to do their work more quickly?

MR. HASTINGS:—Nothing except these sheets. Many companies have a bible, as they call it, which, if it is good at all, gradually grows so bulky that the average man does not take the trouble to read it; so, we have avoided anything of that kind. We have tried to make anything we give the men intensely practical.

If a man finds out or thinks that the routine is wrong or that some other way is better, we encourage him to try it, to let the foreman know what he is doing and work it out. If a man finds a method that is better, we cheerfully rewrite the instructions and adopt the new method. When that is done, we put a note on the bottom margin, "Rewritten," and date it to make sure that the later sheets are all distributed. We have a suggestion box and pay from $2 to $5 for each good suggestion. Suggestions of this sort are cashable propositions for the men.

MR. LORD:—When dealing with high-priced cars where the percentage of chauffeurs is high, would you stick to a flat-rate plus material charge? There is a demand, as you have brought out, to know beforehand what the job will cost. When the owner is farther away from the car, as is the case with a higher-priced car with a chauffeur, it is a question whether he would not want a flat figure for the job, parts and labor.

MR. HASTINGS:—That is easily taken care of; you can tell him that the labor will be so much and that the rest will depend on what parts are required, that there will be a maximum figure for parts, and so on. I would not try to make a definite figure for parts before the job is started. I would give a flat figure for labor, so far as I could, except in the case of wreck jobs and work of that kind, and a maximum figure for parts, depending on the nature of the work to be done.

H. N. DAVOCK:—We have a definite charge for the labor required for the inspection to find out how much the material will be, and then we tell the owner definitely what the total charge will be. I think that is necessary in many instances.

MR. HASTINGS:—We have that system, also. We find that it means a telephone call to the owner; he will not wait while you are making the inspection. We do that when an owner wants to know definitely just what the cost will be but, in our experience, the average owner is not concerned so much with the cost of parts as he is with the labor.

MR. DAVOCK:—Why?

MR. HASTINGS:—Because the parts have a fixed price. He knows that if he gets a piston he must pay so much; the price cannot be juggled. We charge the factory list-price plus 5 per cent for parts.

MR. PAGE:—I think you are contradicting yourself, because you have said truly that the car-owner today wants to know how much a repair job will cost. The car-owner does not want the labor and parts separated; he wants to know exactly what the job will cost, complete.

MR. HASTINGS:—If the owner is willing to wait or to depend on a telephone call, we tell him gladly what the complete cost will be, but the average owner will not wait. He wants to get out of the door and to his work in the shortest possible time. Some owners ask us to call back, or they call in the course of an hour or two; in those cases we give the complete price.

MR. DAVOCK:—We find that, on a small job, in 95 per cent of the cases, we can give the cost of labor and material, and that when we get a big job requiring inspection, the owner is anxious to know whether it is a $200 or $300 job, and he wants to know what the material cost will be just as much as he wants to know about the labor charge. The material must be averaged, just as the labor must be averaged now; we believe that this is just as permissible with material as it is with labor.

MR. HASTINGS:—Yes, I think it is permissible. As I have said before, the owner is not interested so much in the actual amount that he must pay as he is in knowing the amount beforehand. If a man wants a new front fender, let us say, we may have to put in some new bolts or a new anti-squeak strip, or something like that, or we may not; 50 cents to $1 will cover the difference; and I think it is entirely permissible as you say, to average the price on that basis.

MR. DAVOCK:—You can average the material closely enough, and then you are exact and do not leave any loop-holes for argument or question.

MR. PLUMRIDGE:—Probably some will doubt whether you put the parts in.

MR. HASTINGS:—We save the old parts and give them to the owner with our compliments.

MR. GARDNER:—It really is a very short step from the ordinary system to the flat-rate system because, on almost all jobs nowadays that amount to $75 or more, you are obliged to submit an approximate estimate. In the last 4 or 5 years, in our service-station, the number of jobs that we have been called on to estimate has gradually increased.

MR. HASTINGS:—You probably spend as much time estimating on jobs as would be required to put in a flat-rate system.

MR. GREENAMYER:—On the write-up sheets that our service salesman has, there is printed, "Do or do not save old parts." It takes about 10 sec. to find out whether the owner wants the old parts saved. If he does, they are put into his car and he takes them away with our compliments. In case an operation can be shortened and a saving effected, do you leave the flat-rate as originally set, or do you give the customer the benefit; if so, what percentage do you keep to cover the overhead and lost production?

MR. HASTINGS:—We have had cases like that. One of them in particular was a rattling in the steering-gear between the control tubes. We devised a tool for expanding the tubes to fit the bushing, rather than trying to ream the bushing to fit the tube. The bushing is thin-walled and the tubes vary in diameter from end to end, so we leave the tube in position, hit the tool with a hammer and expand the tube to fit the bushing; that takes out the rattle. Instead of its being a 2½-hr. job, which it probably would average with new bushings, new tubes and so on, it is about a 20-min. job to take it apart, expand the tube and reassemble it. We have an account that we call "use of special equipment," to which we charge a certain percentage of the saving in such cases. We give the owner about 75 per cent of the saving, take about 25 per cent ourselves and reduce the rates accordingly.

MR. COBLEIGH:—The suggestion about returning the old parts was good but I did not like the expression, "With our compliments." The parts belong to the owner, unless you allowed something for the old parts when you

sold him the new ones. But aside from that, it is a wise thing to do, because it convinces the owner that the parts he bought actually went into the car, and will help to regain the public confidence.

MR. LORD:—The difference between the owner-driven car and the chauffeur-driven car comes up again; that is, the question of how much advantage there is in returning parts to the chauffeur-driven vehicle. With high-priced chauffeur-driven cars, you will find that a large majority of the owners never drive the cars and do not know anything about them.

MR. HASTINGS:—For that reason I think you should go to the owner. We have a man who does nothing but talk to owners part of the time; we do not keep him at that regularly.

MR. LORD:—To discuss repairs?

MR. HASTINGS:—Yes, and to find out whether the car is satisfying the owner; if there is anything that does not satisfy him, to find out about it and take steps to correct it. Certain owners will not come to you; you must go to them.

MR. LORD:—We get along finely with owners who drive their cars; it is those who insist on doing business with us through their drivers that we are more liable to get into more or less serious trouble with.

MR. HASTINGS:—I had an example of that recently; it is not exactly parallel, but is similar. A man bought a sedan last February. He says, and I cannot dispute him although he cannot prove it to me, that he has had constant trouble with his starter sticking. Occasionally a soft flywheel will get through. He says he has had constant trouble for 11 months; yet, the first I heard of it was last week. He is as sore at us as it is possible for a man to be, yet he has not come to us and told us of his troubles. It puts us in a very awkward position. If we had known of this months ago, it would have been a simple matter to fix it and satisfy him; so I say there are certain owners that you must go to instead of waiting for them to come to you.

MR. PLUMRIDGE:—I believe 50 per cent of the trouble could be avoided if you would educate the owner to know something of the work that must be done to the car to put it in serviceable condition.

MR. HASTINGS:—The education of owners, though, is a long and difficult task.

MR. PLUMRIDGE:—If a technical man could talk to those men in such a way that they could understand it, it would help very much.

1922 RETURNS TO AMERICAN FARMERS

A RETURN of $917 to the owner operator for the use of $16,400 of capital and the labor of the farmer and his family during the year 1922 is the average shown by a survey of over 6000 representative farms just completed by the United States Department of Agriculture. These farms average somewhat larger in size and value than the average of the United States, according to the 1920 census.

This return included $715 cash, the margin of receipts over cash outlay, plus an increase of $202 in inventories of crops, live stock and machinery. In addition, the average farm produced food and fuel consumed on the farm, estimated to be worth $294. This $715 cash balance was all the average farm made available to the owner to pay his living expenses and take care of debts.

The results of the operations on individual farms, which make up the average of $917, ranged from a margin of $58,000 of receipts over expenses to a deficit of $34,000 of receipts under expenses. Fourteen per cent of the farms failed to break even, the survey shows. About two-thirds of the farms returned less than $1,000 each. Twenty-eight per cent returned $1 to $500; 23 per cent returned between $500 and $1,000; 14 per cent between $1,000 and $1,500; 7 per cent between $1,500 and $2,000, and only 8 per cent or one farm in every twelve returned more than $2,500 net for the year.

The size of the farms was 252 acres on the average, and the reported value of land and buildings $13,600. The value of crops, live stock and machinery on hand at the beginning of the year was $2,800, making a total capital of $16,400.—*Economic World.*

PETROLEUM PRODUCTS

A REVIEW of refinery production in the United States for a few recent years, covering the four chief petroleum products, shows that the output of gas and fuel oil and of gasoline has made an unbroken advance, while that of the other major products showed a decline in 1922 from the high marks reached earlier. Production in millions of 42-gal. barrels was as given in the accompanying table.

Year	Gas and Fuel Oil	Gasoline	Kerosene	Lubricating Oil
1916	111	49	35	15
1917	155	68	41	18
1918	174	85	43	20
1919	182	94	56	20
1920	211	116	55	25
1921	230	123	46	21
1922	255	148	55	23

So far the supply of fuel oil, although dependent rather upon the production of gasoline than upon the demand for oil, has not limited the extension of its use, except insofar as advancing prices have in some fields placed it beyond the level of competition with coal. For those purposes for which it has special advantages, such as marine fuel, its use will probably continue to be extended. In other fields the use of fuel oil will be determined by the availability and relative cost of coal; here freight and labor charges and the location of deposits will be important factors.—*Commerce Monthly.*

Vol. XII June, 1923 No. 6

Gear-Grinding and Tooth-Forms

By GLENN MUFFLY[1]

DETROIT SECTION PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

THE production of noiseless gears requires that minute errors in tooth-curves be avoided. Objectionable sound-waves are caused by a gear-tooth error of 0.0003 in. and, as steel cannot be depended upon to go through the heat-treating process and retain so great accuracy as this, the teeth must be ground after they have been hardened; and the grinding operation must be a generating process. The old method of cutting involute teeth with a formed cutter demanded close adherence to the pitch-diameter and no mention was made of the base-circle, which is the basis of modern practice.

After demonstrating the elementary principles involved in the development of the involute curve and showing the relations of the pitch-diameter, the pressure-angle, the pitch and the form of the tooth, and of the base-circles and the pitch-circles and the base-circle tangents that cross at the point of pitch-circle contact, and, similarly, beween the last named and the rack profile with its straight pitch-line, tangent to the two pitch-circles, the author proves that the rack profile moving in synchronism with the pitch-curve will generate the same involute curve as that developed from the base-circle. Consequently, the straight line of the rack tooth is used to generate involute gear-teeth and the cutting tool is moved tangentially at the same velocity as the gear rotation on the pitch-circle. This principle is then applied to hobbing, in which case the gear rotates while the rotation of the hob provides the tangential movement of the tool. The modern process of gear-cutting that is described employs the same principle and has the same relative motion, but it is the gear that moves.

The relative movement between the work and the grinding-wheel is obtained by tapes and segments or circles, the diameter of the segment or circle being the pitch-diameter of the gear less a certain allowance on account of the thickness of the tape, and the effective radius being practically the radius of the segment plus one-half the thickness of the tape. The difficulty encountered due to the variation of the torque as the gear-tooth rolls into and out of engagement with the grinding-wheel is overcome by applying the power to the spindle carrying the gear instead of to the slide.

The method of determining the maximum width of face that can be ground is given and the details of construction of the machine used in grinding by this method are discussed, as is also a gear-testing machine for measuring the microscopic variations from theoretically perfect ground gears, and for showing where and by how much a gear varies from a true involute. Inasmuch as the real test in the prevention of noise is the tooth-to-tooth difference in spacing, which must be uniform, and to provide the greatest possible accuracy, the index plates were obtained from an astronomical dividing-engine.

Changing the relation of the rotation to the slide-travel will modify the tooth-curve. As all modern tooth-forms are based on the involute principle the process described can be used for teeth of a special form, the differences between the tooth-forms being due to differences of the pressure-angle. By eliminating noise, grinding makes possible the use of hardened gears that heretofore could not be made quiet and, likewise, opens the way for greater use of four-speed transmissions that would enable engines to be run within their most efficient range for the greater part of the time. A 6 or 7 to 1 acceleration with a four-speed transmission would be more satisfactory than a 5 to 1 acceleration with direct drive. Quiet gears also are more efficient. Because of the accuracy with which spur gears are now ground it is possible that they will replace helical timing-gears and chain drives.

[1] M.S.A.E.—President, Muffly Mfg. Co., Cleveland Heights, Ohio; sales manager, Lees-Bradner Co., Cleveland.

WE have found in developing our gear-grinding process that objectionable sound-waves were produced by a gear-tooth error of 0.0003 in. To make transmissions that will pass rigid inspection, we must first find this minute error and measure it, and then eliminate it from production. Steel cannot be depended upon to go through heat-treatment and come out so accurate as this. We must, therefore, generate the tooth-curves after the steel has been heat-treated instead of before. I say "generate" advisedly, for it is out of the question to hold formed wheels or cutters within such narrow limits. The only answer, then, is to grind gear-teeth *after* hardening, just as we have for years been grinding many parts of less importance; and the grinding operation must be a generating process.

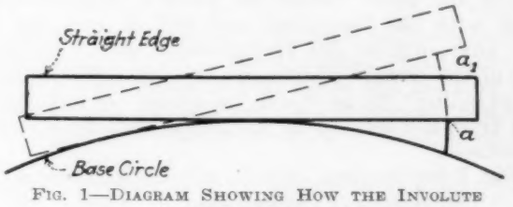


FIG. 1—DIAGRAM SHOWING HOW THE INVOLUTE CURVE IS DEVELOPED

The purpose of this paper is to show how gear-teeth are being ground within this new limit of accuracy in regular production and how the minute errors in tooth-curves and spacing may be measured. The process goes back to first principles; so we shall start by considering the elementary principles that are more or less obscured in the older processes in which there are one or more steps between the principle and the finished gear.

The involute system was invented before generating machines were available. The old method of cutting involute teeth with a formed cutter demanded close adherence to the pitch-diameter for which the cutter was made in order to reproduce the desired tooth-form. The gear books of that time emphasized the maintaining of the pitch-diameter. All calculations were based on the pitch-diameter and no mention was made of the base-circle at all. Now that we are getting back to first principles and generate gear-teeth from the straight line of a rack tooth we shall have to forget the old ideas and begin to think more about the base-circle diameter.

INVOLUTE CURVE DEVELOPMENT

In Fig. 1 we see how the involute curve is developed. The involute curve on a spur gear is always the involute of a circle. There are involute curves developed from

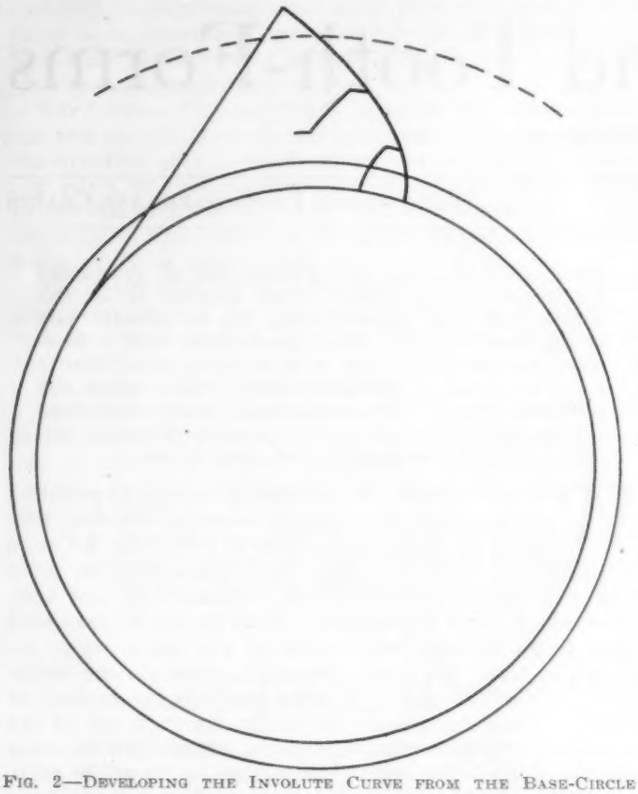


FIG. 2—DEVELOPING THE INVOLUTE CURVE FROM THE BASE-CIRCLE

other figures, but so far as we are concerned there is only one involute curve, that developed from the base-circle of the gear. When we place a straight-edge in contact with the base-circle and roll it upon the base-circle, any point on the straight-edge will trace the involute of the circle. Tracing an involute curve is similar to "unwinding" it, as it can be traced by unwinding a string from the base-circle, assuming that the string has no thickness.

In Fig. 2 the involute curve is developed from the base-circle, which is always smaller than the pitch-circle. Selecting a pitch-diameter as represented by the larger circle of the two, we use the lower portion of the curve

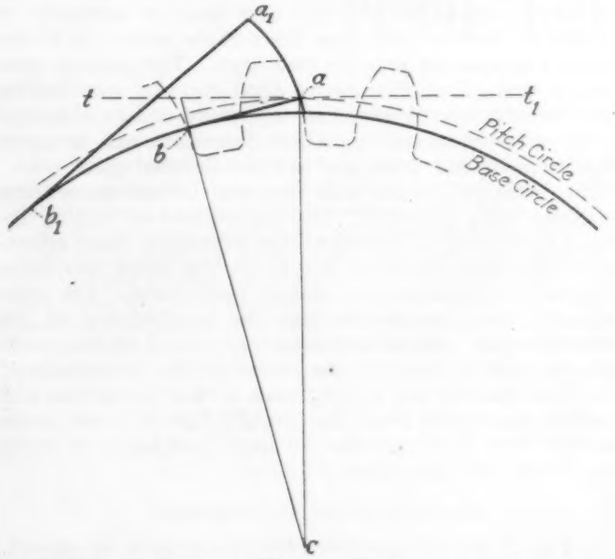


FIG. 3—DIAGRAM SHOWING HOW THE RADIUS OF THE BASE-CIRCLE IS DETERMINED WHEN THE PITCH-DIAMETER IS KNOWN

in making a tooth as shown, or we can go farther out and construct another tooth of greater pressure-angle, as is indicated. If we were to go still farther out and select a pitch-circle, as is indicated by the dotted line, we should have a still greater pressure-angle. The selection of the pitch-diameter determines the pressure-angle. We can then determine how many teeth we shall put into this circle, thus establishing the pitch of the gear; and we decide how much of the involute curve we shall use above and below the pitch-circle, thus deciding whether the tooth shall be of standard depth, a stub tooth, or of some special form.

In actual practice we are more apt to start with a desired pitch-diameter than with a given base-circle; so we shall proceed as shown in Fig. 3. Starting with a pitch-circle of known diameter we draw the tangent $t\ t_1$.

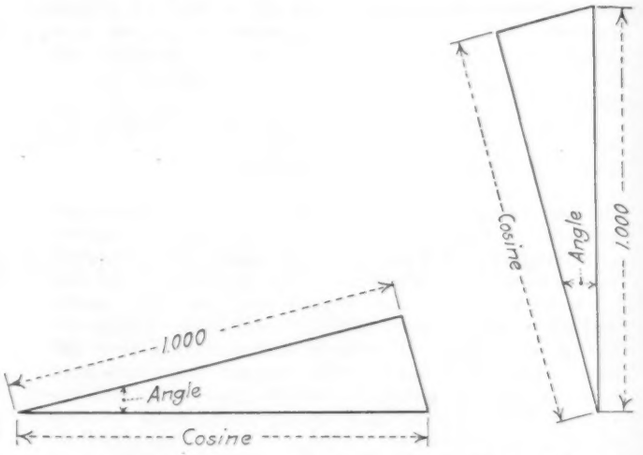


FIG. 4—DIAGRAMS SHOWING THE RELATION BETWEEN THE PITCH-DIAMETER, THE PRESSURE-ANGLE AND THE BASE-CIRCLE

Next we decide what pressure-angle we shall use, say 20 deg., and we draw the line $a\ b$ at an angle of 20 deg. with the tangent, crossing the pitch-circle and tangent at the point of tangency. Now we drop a perpendicular from the center c to the line $a\ b$ and with the line $c\ b$ as the radius we draw the base-circle. Referring to previous figures, it will be seen that the line $a\ b$ is tangent to the base-circle and the point a will describe the involute curve $a\ a_1$, when the tangent is rolled upon the base-circle. We now have the right-angled triangle $a\ b\ c$ of which we know the side $a\ c$, the radius of the pitch-circle with which we started. We also know that the angle $b\ c\ a$ equals the angle $b\ a\ t$ since each of them is equal to one right-angle minus the angle $b\ a\ c$. Knowing the hypothenuse and one angle of this right-angled triangle we can find the length of the side $b\ c$, which is the radius of the base-circle.

In Fig. 4 we have a diagram showing how this is done. If the hypothenuse is 1, the length of the base-line will be the cosine of this angle. Turning the triangle over and rotating it until its position coincides with the position of triangle $a\ b\ c$ in Fig. 3, we see that the length of the line $b\ c$ is found by multiplying the length of the line $a\ c$ by the cosine of the pressure-angle. Therefore, we have the rule which may be stated as follows; the pitch-diameter multiplied by the cosine of the pressure-angle equals the diameter of the base-circle.

Fig. 5 is a familiar illustration showing the relation of the base-circles and the pitch-circles to the base-circle tangents crossing at the point of pitch-circle contact. Following through the tracing of the involute curves for

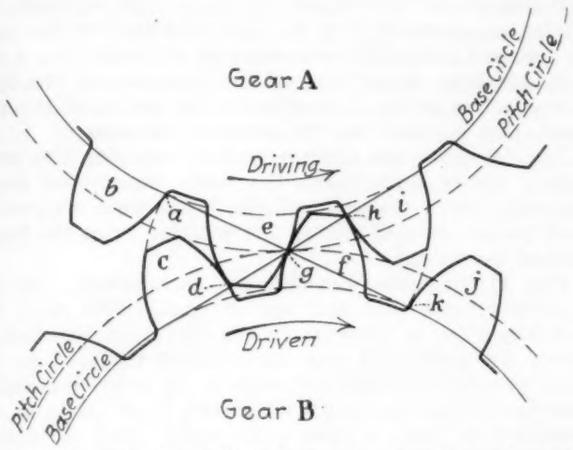


FIG. 5—RELATION OF THE BASE-CIRCLES AND THE PITCH-CIRCLES TO THE BASE-CIRCLE TANGENTS CROSSING AT THE POINT OF PITCH-CIRCLE CONTACT

each side of each tooth of each gear, it will be found that point *a* traces the driving side of booth *b*, also the driven side of tooth *c*, and so on for the other teeth, thus proving that the involute theory is correct.

Fig. 6 is a similar diagram, showing also the rack profile, which has a straight pitch-line, tangent to the two pitch-circles. While the point *l* on the rack pitch-line moves to the point *m*, the same point on the base-circle tangent moves to the point *n*. For any specified amount of angular movement the distance *l-m* will be to the distance *l-n* as *l* is to the cosine of the pressure-angle. It is also shown that the point *n* has not only traced the curves of two teeth but has also traced one side of the rack

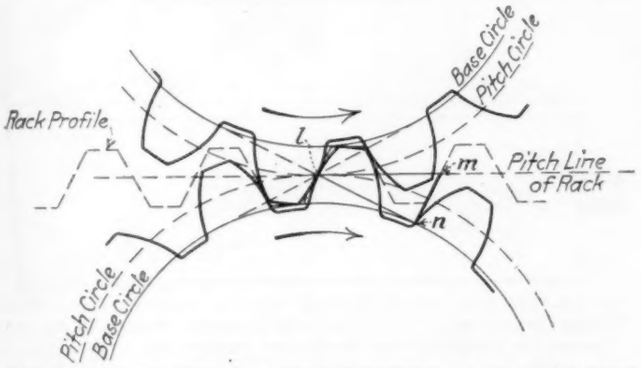


FIG. 6—DIAGRAM, SIMILAR TO THAT REPRODUCED IN FIG. 5, SHOWING IN ADDITION THE RACK PROFILE, WHICH HAS A STRAIGHT PITCH-LINE, TANGENT TO THE TWO PITCH-CIRCLES

tooth, which is a straight line. We can thus prove that the rack profile moved in synchronism with the pitch-circle will generate the same involute curve that we developed from the base-circle. To generate a tooth-curve from the base-circle our cutting-tool would have to be a point and consequently the operation would be very slow. For this reason the straight line of the rack tooth is used to generate involute gear-teeth and the cutting tool is moved tangentially at the same velocity as the gear rotation on the pitch-circle.

In Fig. 7 we see this principle as applied in hobbing. In this case the gear rotates while the rotation of the hob provides the tangential movement of the tool.

GEAR-TOOTH GRINDING

The process of gear-tooth grinding that we use employs the same principle and we have the same relative motion, though it is the gear that moves, as shown in Fig. 8. The grinding-wheel has a flat side which represents one side of a rack tooth. The gear is rolled along on the rack profile and as it rolls into and out of engagement with the grinding-wheel one side of a tooth is finished. Starting from the position *o* the gear rolls past

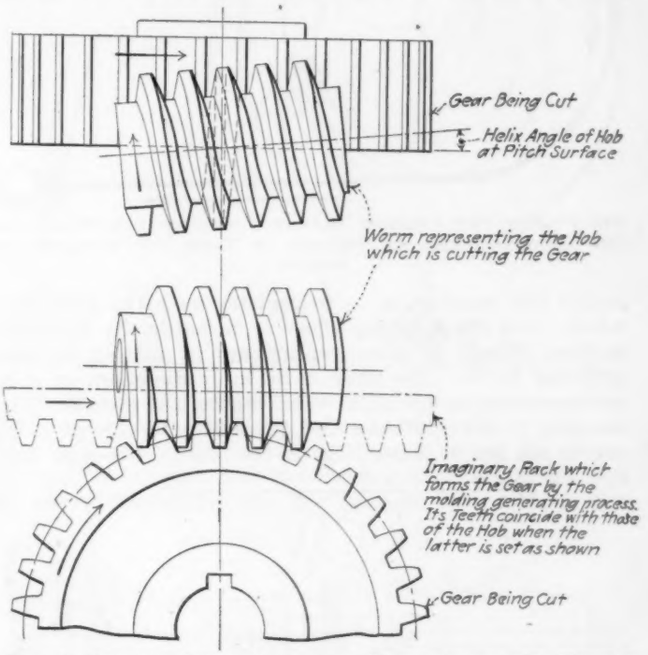

Gear Being Cut
Helix Angle of Hob at Pitch Surface
Worm representing the Hob which is cutting the Gear
Imaginary Rack which forms the Gear by the molding generating process. It's Teeth coincide with those of the Hob when the latter is set as shown
Gear Being Cut

FIG. 7—DIAGRAM ILLUSTRATING THE PRINCIPLE OF THE HOBBING PROCESS FOR FORMING SPUR GEARS

the wheel to the position *p*, reverses and rolls back to the position *o* thus passing over the wheel twice. The gear is automatically indexed at this point and the next tooth is rolled over the wheel twice. This operation continues until the gear has made a complete revolution, or in some cases two complete revolutions.

When the gear is first placed on the machine it is

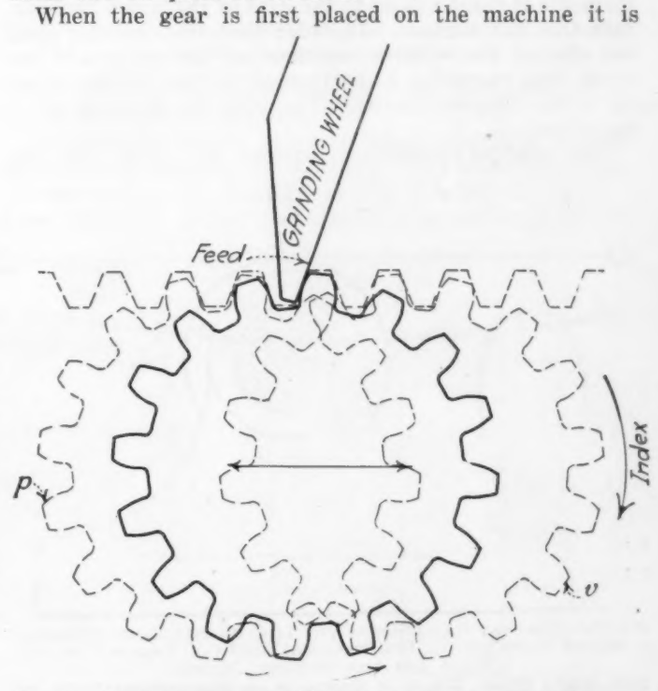


FIG. 8—APPLICATION OF THE HOBBING PRINCIPLE TO THE GRINDING OF GEAR-TEETH

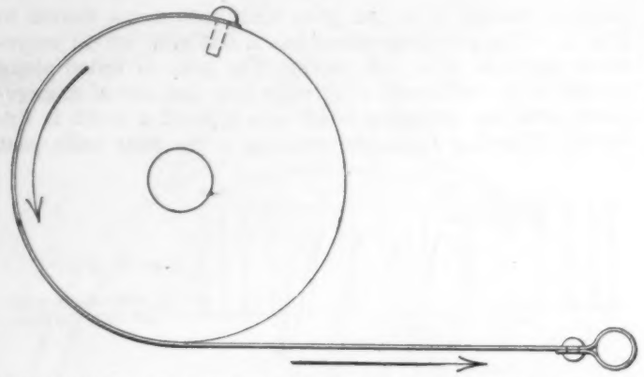


FIG. 9—HOW THE RELATIVE MOVEMENT BETWEEN THE WORK AND THE GRINDING-WHEEL IS OBTAINED BY TAPES AND SEGMENTS OR CIRCLES

locked into position so as to register with the grinding-wheel; then the grinding-wheel is moved in the direction marked "Feed" by whatever amount is allowed for the grinding finish. The wheel is 30 in. in diameter, so it is not necessary to dress the wheel during the process. The dressing is done between the gears at intervals of from one to six gears, depending on the size of the gear and

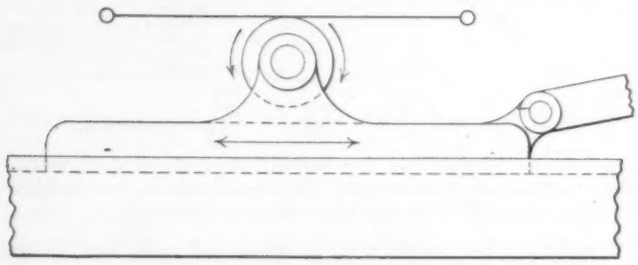


FIG. 10—THE OLDER METHOD OF APPLYING THE TAPE AND SEGMENT PRINCIPLE

the amount of metal removed. Since we are using the flat side of the wheel it is necessary only to move the diamond at right angles to the axis of the wheel to maintain this flat surface. In order that the dressing shall not change the relative positions of the wheel and the work, this operation is performed by moving the wheel up to the diamond instead of moving the diamond up to the wheel.

The relative movement between the work and the grinding-wheel is obtained by tapes and segments, or circles, as shown in Fig. 9. The diameter of the circle or segment is the pitch-diameter of the gear, less a certain allowance on account of the thickness of the tape. The effective radius is practically the radius of the segment, plus one-half the thickness of the tape.

Fig. 10 shows the older method of applying this principle. The slide carrying the work was moved longitudinally while the ends of the tapes were secured to fixed points, thus obtaining the rotation from the longitudinal movement.

Fig. 11 illustrates the difficulty encountered. As the gear-tooth rolls into and out of engagement with the grinding-wheel a variaion in the torque is required to rotate the gear, and this variation of the load on the tapes produces a slight variation in the relative angular-velocity. When working within such close limits as are necessary to make a spur gear really quiet we cannot afford to let even such a slight error as this pass. The resulting error is shown in exaggerated form by the inserted tooth-profile at the left.

Our method of overcoming this difficulty is shown in Fig. 12. Power is applied to the spindle carrying the gear instead of to the slide. The frictional resistance to the slide movement is constant, since it is governed by gravity alone. The acceleration and the deceleration of the slide movement occur while the gear is not in mesh with the grinding-wheel.

The two tapes are attached to a tape-bar supported by

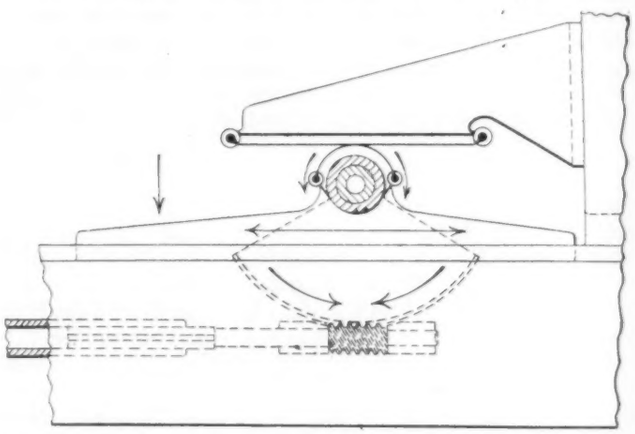


FIG. 12—APPLYING POWER TO THE SPINDLE CARRYING THE GEAR INSTEAD OF THE SLIDE CARRYING THE GRINDING WHEEL IS RELIED UPON TO OVERCOME THE DIFFICULTY ILLUSTRATED IN FIG. 11

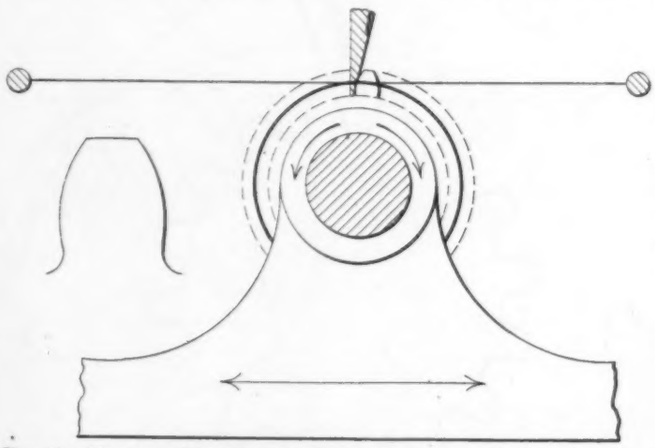


FIG. 11—HOW THE VARIATION IN THE LOAD ON THE TAPES PRODUCES A SLIGHT VARIATION IN THE RELATIVE ANGULAR VELOCITY OF THE WORK AND THE GRINDING WHEEL
This Slight Error, Which Is Shown in an Exaggerated Form by the Tooth Profile at the Left, Produces a Noisy Gear

a heavy overhanging head, as shown in Fig. 13. Vertical and horizontal adjustments are employed only in setting-up.

In Fig. 14, which shows an elevation of the complete machine, we can see these various elements in relation to one another. The spindle that carries the grinding-wheel is arranged to swivel for various pressure-angles and the saddle that carries it has a vertical adjustment for various diameters of work.

The relation of the grinding-wheel to the gear is shown again in Fig. 15. The angle of the grinding surface with the perpendicular is equal to the pressure-angle; in other words, the angle between the grinding-wheel spindle and the direction of work-travel is the pressure-angle. On account of the large diameter of the grinding-wheel it is not necessary to travel the wheel along the axis of the gear.

Fig. 16 shows the longitudinal section of the work-spindle as viewed from the front of the machine. On the

left we have the index mechanism, in the middle the tapes and the segments and at the right the gear that is being ground. The arc of the grinding-wheel is shown in part. The indexing is obtained from hardened steel plates, a different plate being used for each number of teeth. In setting-up the machine we put on the proper index-plate for the number of teeth, the segment and the tapes for the required pitch-diameter and a suitable arbor or fixture for holding the gear. The grinding-

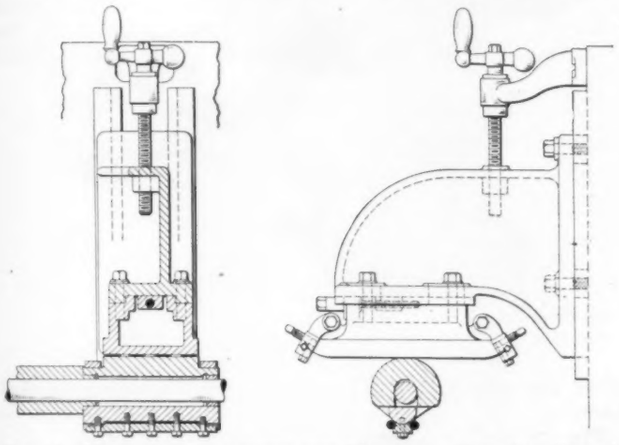


FIG. 13—METHOD OF ATTACHING THE TAPES TO A TAPE-BAR THAT IS SUPPORTED BY A HEAVY OVERHANGING HEAD

wheel spindle is then set at whatever pressure-angle we wish to grind and the head is adjusted vertically for the diameter of the gear. The grinding-wheel is not changed,

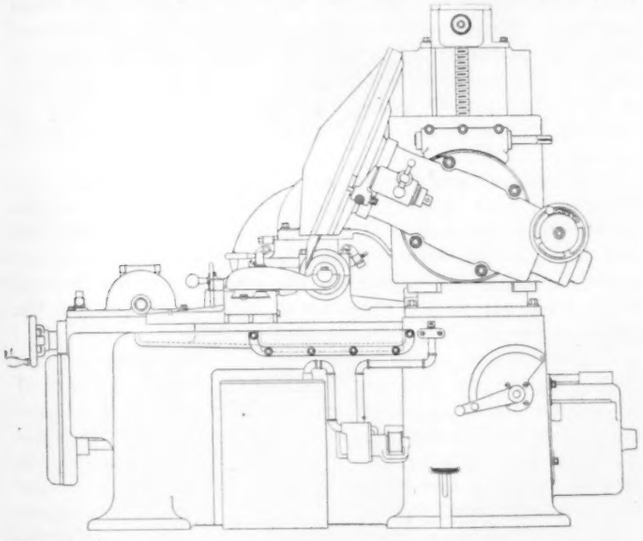


FIG. 14—ELEVATION OF THE COMPLETE GEAR-GRINDING MACHINE

as all pitches and pressure-angles are ground with the same flat surface.

Fig. 17 shows how to determine the maximum width of face that can be ground. It is, of course, necessary that the wheel should clear the full depth of the gear in the middle of the face, or the points r and s in the case of two gears with a space between them, and that the wheel should come down to the full working depth at points t and u. On a six-pitch gear of standard clearance we can grind 1¾ in. of face. If it is necessary to grind a wider face the gear can be roughed-out with more clearance at the bottom to allow for setting the wheel in to the required depth.

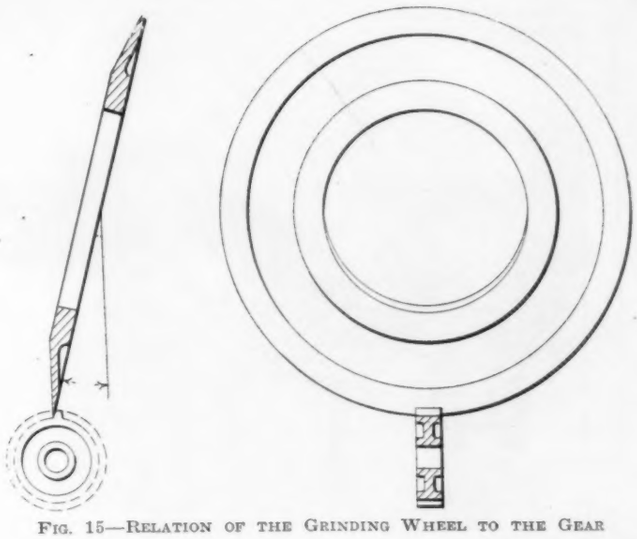


FIG. 15—RELATION OF THE GRINDING WHEEL TO THE GEAR

At the left of Fig. 18 is a view of the machine as seen by the operator, while the other portion of the illustration is a rear view of the machine showing the drive-pulley, the housing over the index mechanism at the end of the work-spindle, and the gearbox that controls the

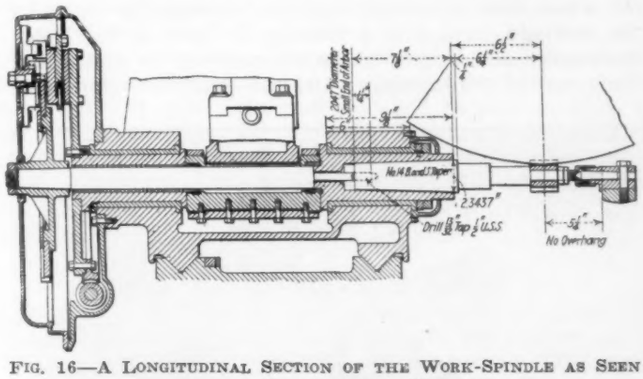


FIG. 16—A LONGITUDINAL SECTION OF THE WORK-SPINDLE AS SEEN FROM THE FRONT OF THE MACHINE

rotation of the work, and through this, by means of the tapes, the travel of the table.

A foot-brake on the grinding wheel spindle is used to save time in stopping the machine. The tape-clamps and the tighteners are mounted on the tape-bar to which I have referred. Other features include the segment-roll

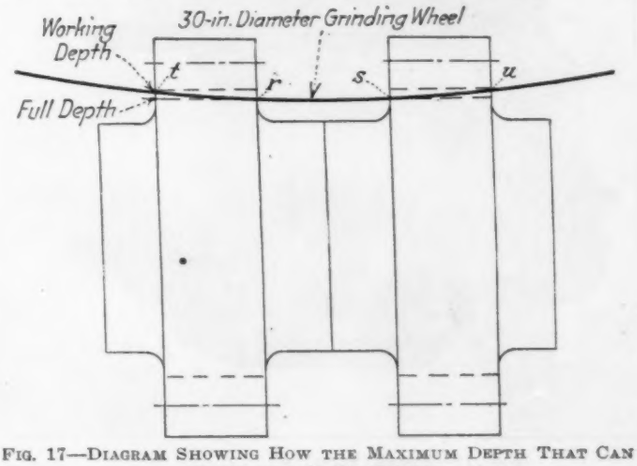


FIG. 17—DIAGRAM SHOWING HOW THE MAXIMUM DEPTH THAT CAN BE GROUND IS DETERMINED

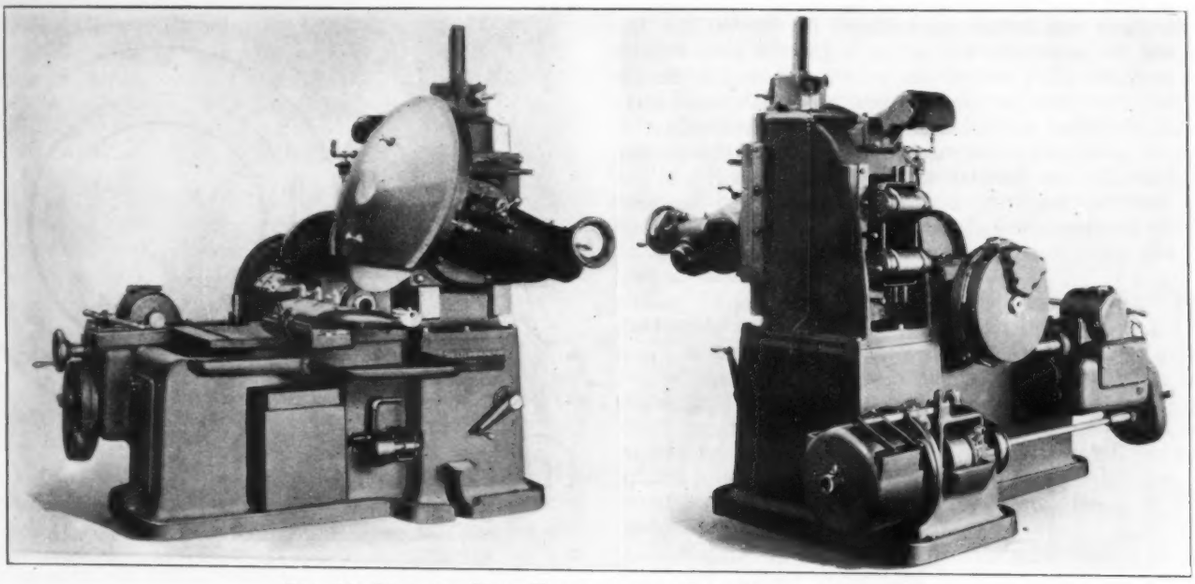


FIG. 18—SIDE AND REAR VIEWS OF THE GEAR-GRINDING MACHINE

on which is mounted the segment on which the tapes are wound; the indexing mechanism that automatically indexes the gear from tooth to tooth between passes over the wheel; the adjustable stops for varying the travel of the carriage, located in a housing in front of the index mechanism and directly above the gearbox for controlling the speed of the carriage; and the handwheel for actuating the carriage, which is used only in setting-up the machine.

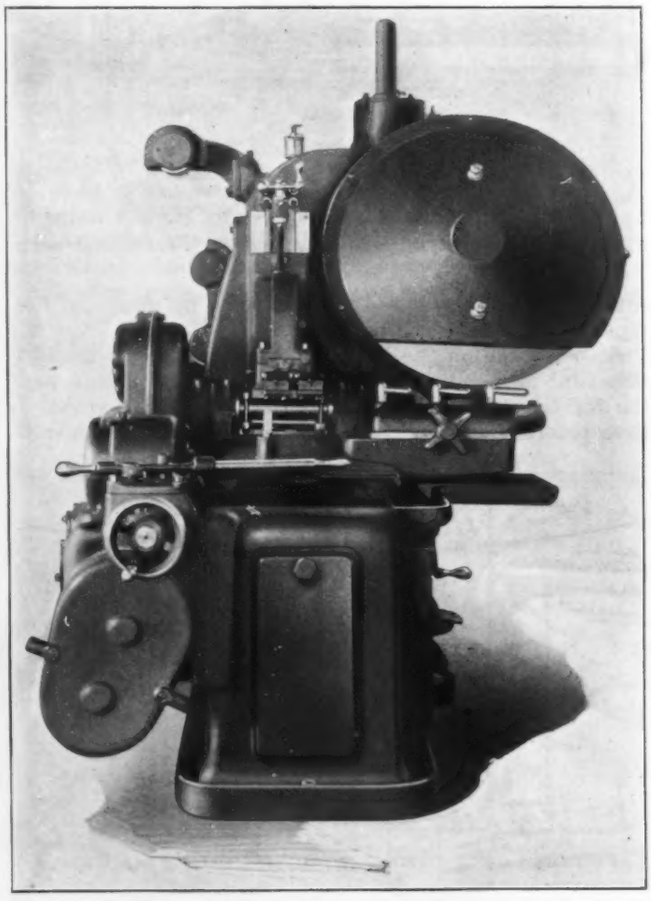


FIG. 19—FRONT VIEW OF THE MACHINE

Fig 19 is a front view of the same machine.

Fig. 20 shows the grinding-wheel head. At the left side is the ball-crank that actuates the diamond by a worm and worm-gear. The adjustable diamond-holder is carried by a crank on the worm-gear shaft and the diamond itself is adjusted against a hardened-steel block that definitely establishes the plane of the grinding-wheel surface. The handwheel, shown at the lower right-hand side, is used for the dressing that is accomplished by feeding the wheel up to the diamond. It is provided with a stop that moves as the wheel is dressed, so that in making the setting for any gear the wheel always stops in the same plane.

The worm and worm-gear adjustment above the spindle is used in setting the head at the pressure-angle as shown on a vernier dial. If the operator should set the head at the wrong angle he will grind a different pressure-angle but will keep the correct pitch-diameter. Such an error would show-up at once when testing the gear on the machine shown in Fig. 21.

Since this process is based entirely on elementary principles employing straight lines and circles instead of master forms of any kind, it is much easier to hold production to an exact standard than when the accuracy depends on outside sources. The process and the operation of the machine are simple enough to be placed in the hands of unskilled operators, but, of course, the supervision and the inspection should be in competent hands.

TESTING GEAR-GRINDING ACCURACY

Fig. 21 is a general view of the gear-testing machine that we found it necessary to design to measure the microscopic variations from theoretically perfect ground gears.

At the left of Fig. 22 is a top view of the machine before the gear is placed on it. A disc is ground to the base-circle diameter and placed on the work-arbor. The tangent-bar, or straight-edge, is held against the base-circle by the two ball-bearings on the slide-frame under spring tension. As the slide-frame is rotated upon the work-arbor the tangent-bar rolls about the base-circle and the point of the contact-lever traces the involute.

The central portion of the illustration shows the gear to be tested in place. If the tooth-curve is a perfect involute the indicator will stand at zero while the contact-point travels from the base-circle to the point of the tooth. The graduations on a cross member of the slide-frame, just below and to the left of the indicator, comprise a travel-scale showing the progress of the point of tangency upon the tangent-bar, and therefore the progress of the contact-point toward the point of the tooth. These are purely arbitrary graduations and need have no numerical unit assigned to them. On a given tooth we find, for instance, that 21 graduations represent the travel from the base-circle to the point of the tooth and we can tabulate a record showing the deviations of the indicator, plus or minus, at each of these lines. In this way we can plot a curve showing where the tooth is high and where it is low. The indicator reading is in tenths of thousandths.

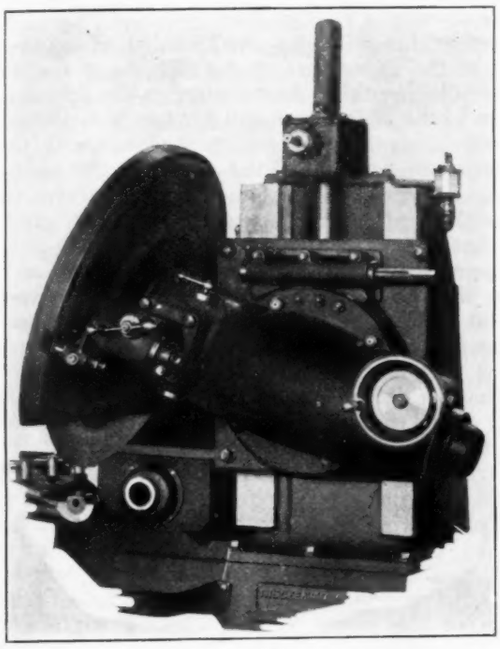


FIG. 20—VIEW OF THE GRINDING-WHEEL HEAD

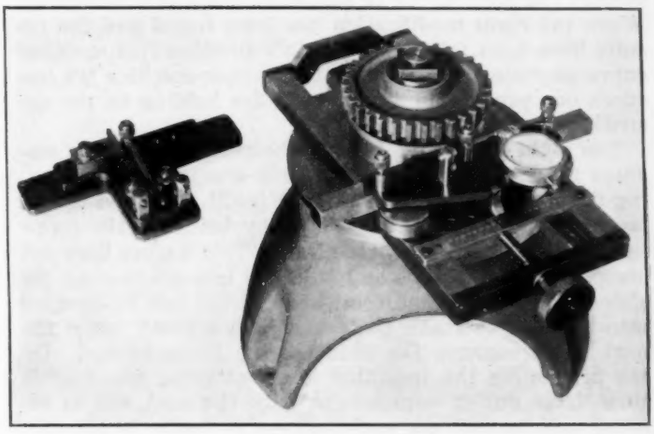


FIG. 21—GENERAL VIEW OF A MACHINE THAT HAS BEEN DEVELOPED TO MEASURE MICROSCOPIC VARIATIONS IN GEARS

There are a number of other methods of testing gear-tooth curves but we have found this method to be most satisfactory for use in connection with our gear-grinding machine because it is necessary to obtain definite measurements. It is not enough to know that a gear-tooth is good or bad; we want to know where and by how much it varies from the true involute. If the gear has a greater or a lesser pressure-angle than the one intended, this fact will show-up at once in a very definite way. It is particularly important that we shall be able to tabulate deviations from the true involute at various points on the tooth because we have found that the perfect involute does not make the most quiet gear. This may seem to contradict my statement, in connection with Fig. 5, that the involute curve is theoretically correct.

TOOTH-SPACING

Carrying the theory just a little farther, it is obvious that we want a true involute curve while the gear is under load, not while it is on the testing-machine. We are working with such minute errors that we must take into consideration the deflection of the tooth under load and

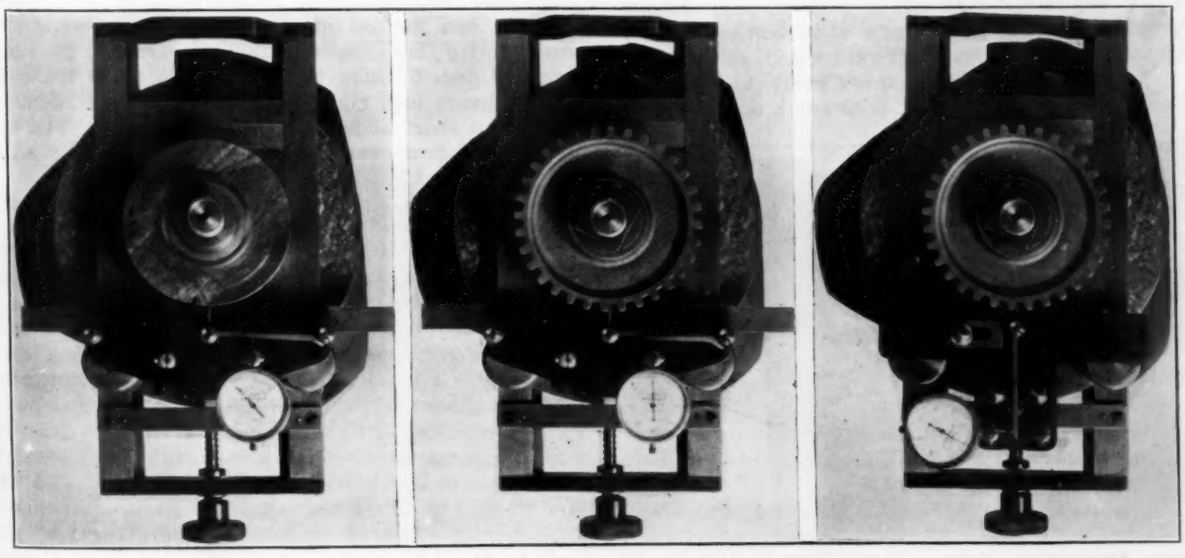


FIG. 22—A SERIES OF VIEWS OF THE GEAR-TESTING MACHINE
From Left to Right These Are a Top View of the Machine, the Machine with the Gear in Place and the Machine Arranged To Test Tooth-Spacing

modify the tooth-curve to compensate for this deflection. When the right modification has been found and the results have been tabulated we can reproduce this modified curve consistently, and with the testing-machine we can check our product to see that we are holding to the desired curve.

The right portion of Fig. 22 shows how this same machine is set-up for testing the tooth-spacing. The indexing fixture, shown at the side in Fig. 21, is placed on the machine and locked into position by bringing the screw tension up against the base-circle. This fixture does not move on the base-circle and is locked into position on the slide-frame. The fixed tooth-stop at the left is clamped into position to make contact with one tooth while the next tooth engages the point of the contact-lever. On the first space the indicator is set at zero; the gear is then lifted out of engagement with the stop and is rotated one tooth. As each successive tooth is brought against the stop the indicator reading is noted. It shows tenths of thousandths, plus or minus, from the setting on the first space, and when we get back to the first tooth again the indicator should have a reading of zero, which shows that nothing has been moved during the test. Similar tests sometimes are made by indicating over several teeth or half-way round the gear, but the real test in the prevention of noise is the tooth-to-tooth difference in the spacing. For instance, we might have a gear on which the readings start at zero on the first tooth, with plus 0.0001 in. on the next tooth, plus 0.0002 in. on the third and so on, half-way round the gear, and then decrease 0.0001 in. on each tooth back to the first tooth. This would be a good gear because the tooth-to-tooth difference in spacing is only 0.0001 in., but if we tested it for the cumulative error half-way round the gear and happened to select the same starting-point, we should get an error of 0.0020 in. on a 40-tooth gear. Another gear might show no error when tested half-way round, but there might be an error of 0.001 or 0.002 in. between two adjacent teeth when tested as shown here. This would not be a good gear.

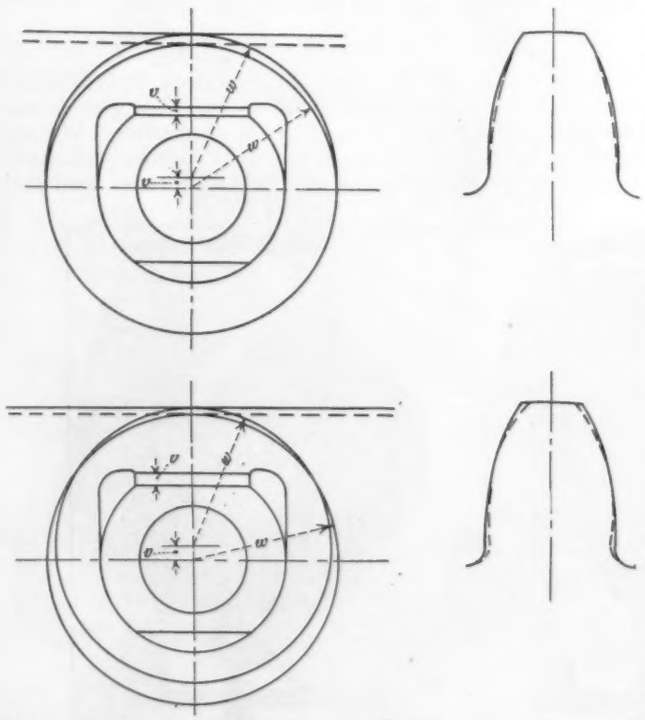


FIG. 23—DRAWINGS ILLUSTRATING THE TWO METHODS OF MODIFYING THE TOOTH CURVES

The Upper Arrangement Gives a Tooth That Is Low in the Vicinity of the Pitch-Line, While with the Other the Tooth-Curve Is Low at Both the Point and the Root

After developing this process to the point of obtaining involute curves that were practically perfect, we found that no existing method of indexing was accurate enough to go with such tooth-curves and it was necessary to devise new means for indexing on the machine as well as new means for obtaining master index-plates. The indexing of the master plates now used was obtained from an astronomical dividing-engine, said to be the most accurate machine of its kind in the world.

MODIFICATION OF TOOTH-CURVES

In connection with the modification of tooth-curves, we see in the upper part of Fig. 23 one of the methods of accomplishing this. Any change in the relation of the rotation to the slide-travel will produce a modification in the tooth-curve. By controlling the change in the relative motion we can control the change in the tooth-curve. This view shows how the shim *v* is placed under the segment without changing the radius *w*. .This produces a tooth that is low in the vicinity of the pitch-line. The lower part shows another modification using a radius, smaller than the standard, that makes the curve low at the point and low at the root of the tooth. These modifications are very minute when compared with the modifications that have been made in the past. The tooth-form that we recommend is so near to the true involute that it would pass for a perfect involute curve when tested by any of the ordinary methods.

We are often asked if this process of grinding will produce gear-teeth of a special form. The answer is yes, so far as any of the well-known tooth-forms of today are concerned, for they all are based on the involute principle. A modication of the clearance at the bottom of a tooth is, of course, a matter entirely aside from the question of the curve on the working surface of the tooth. The differences between these various tooth-forms are only differences of the pressure-angle; in other words, various persons recommend various portions of the same involute curve.

Fig. 24 may appear somewhat startling at first sight, for it shows a gear on which four different pitch-diameters and four different pressure-angles are specified. It has been hobbed at a 20-deg. pressure-angle, and meshes with three gears having a pressure-angle ranging from 18 deg. 37 min. to 22 deg. To make these three mating gears look right we had to put long addenda on two and a short addendum on one of them. The set-up to grind all four gears will be identical, for they all have exactly the same involute curve.

The only difference is that we use a different part of the involute curve on each of the four gears. On the pressure-angle of 18 deg. 37 min. we go down a little closer to the base-circle, and on the 22-deg. pressure-angle we go up a little higher from the base-circle. If we have a pair of 20-tooth five-pitch gears with a 20-deg. pressure-angle, and we mesh these gears on a center-distance of 4.040 in., the gears will be running at a pressure-angle of 21 deg. 30 min. The starting-point is the base-circle, not the pitch-diameter. If the gears have a 20-deg. pressure-angle at a 4-in. pitch-diameter, they will have a base-circle diameter of 3.7588 in., and whenever we go out on the involute curve and establish a new pitch-diameter we can find our pressure-angle by going back to the base-circle, not to the old pitch-diameter. Dividing our base-circle diameter by the new pitch-diam-

eter, 4.040 in., we get 0.93039, which is the cosine of 21 deg. 30 min. 16 sec.

Going back to the four gears shown in Fig. 24, we could set the grinding-wheel at 21 deg. 30 min. and grind all four gears at a 4.040-in. pitch-diameter; we could set the grinding-wheel at 18 deg. 37 min. and grind all four gears at a 3.925-in. pitch-diameter, or we could set the grinding-wheel at a 22-deg. pressure-angle and grind all four at a 4.054-in. pitch-diameter. In each case we should get exactly the same results as if we had used the original 20-deg. pressure-angle on a 4-in. pitch-diameter. Each of the four gears is developed from a 3.7588-in. base-circle.

If you ever have had a pair of gears that were a little tight and you have spread the centers so that they would run better, you have in effect produced a new tooth-form, and if the pressure-angle happened to work-out to 14 deg. 37 min., or 20 deg. 13 min., you might tack your name on that particular pressure-angle and call it your tooth-form. We recently discovered a manufacturer, not 1000 miles from here, who has been cutting gears at 15-deg. 16-min.-pressure-angle for years and did not know that they did not have a 14½-deg. pressure-angle until he started to grind the gears and checked up the tooth profile by the test shown in the central view of Fig. 22.

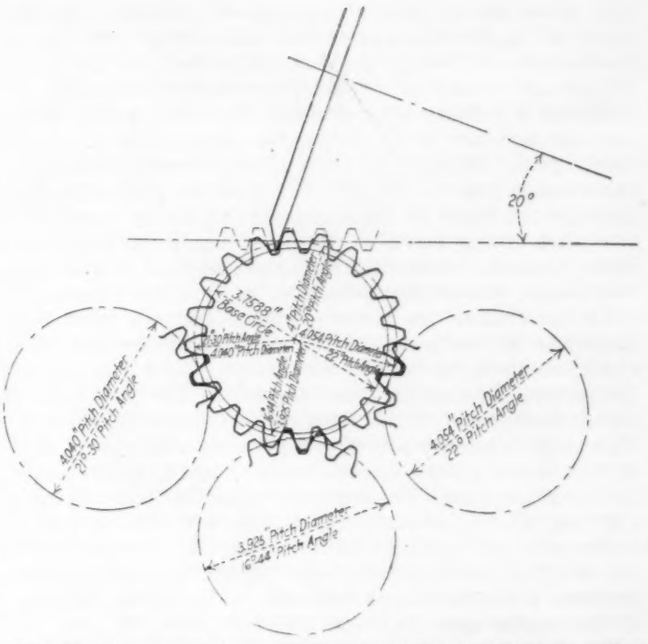


FIG. 24—DIAGRAM SHOWING HOW A GEAR THAT IS GROUND AT ONE PRESSURE-ANGLE WILL MESH WITH THREE OTHERS EACH OF WHICH HAS A DIFFERENT PRESSURE-ANGLE

PITCH-DIAMETER

I have made a working model which will illustrate this sameness of the involute curve for all gears better than I can do it with a drawing. The point I wish to make is that an involute gear has no pitch-diameter of its own and acquires a pitch-diameter only when it is meshed with another gear, or with a hob, a cutter or a grinding-wheel. Consider the gear in the center of Fig. 24. First we grind it by setting the wheel at a 20-deg. angle and using a 4-in. pitch-circle; while grinding it has a 4-in. pitch-diameter; then we take it off the machine, whereupon it loses its pitch-diameter. If we mesh it with the gear on the left, on a center-distance of 4.040 in., immediately the gear acquires a pitch-diameter of 4.040 in. and runs at a pressure-angle of 21 deg. 30 min. If we take the same original gear and mesh it with the gear at the right, or with another gear exactly like it on a center-distance of 4.054 in., both gears immediately acquire pitch-diameters of 4.054 in. and run at a pressure-angle of 22 deg. If we mesh it with the gear at the bottom on a center-distance of 3.925 in., we find that both gears have pitch-diameters of 3.925 in. and run at a pressure-angle of 18 deg. 37 min.

The first thing I learned about a gear had to do with the pitch-diameter and I grew up in the belief that the pitch-diameter was the starting-point, whereas in reality there is nothing at all stable about the pitch-diameter. A pair of involute gears running on a center-distance 0.010 in. greater than the standard are running just as accurately theoretically as if they were meshed on the center-distance for which they were originally intended, except, of course, that a pair of gears to be run in this way should have the teeth cut a little thicker to keep the backlash within reason.

The device at the extreme left of Fig. 25 is a working model of the diagram shown in Fig. 5. The center-distance is 16 in. and the two base-circles are of the proper diameter to give us a 20-deg. pressure-angle. The distance from the center of the smaller gear to the point at which the tapes cross is to the distance from the center of the larger gear to this point as the diameter of the smaller base-circle is to the diameter of the larger base-circle. No matter to what center-distance we move these base-circles, there respective centers will be proportionately distant from the point of tape-crossing.

We attach a pencil *A* to one of these tapes so that it

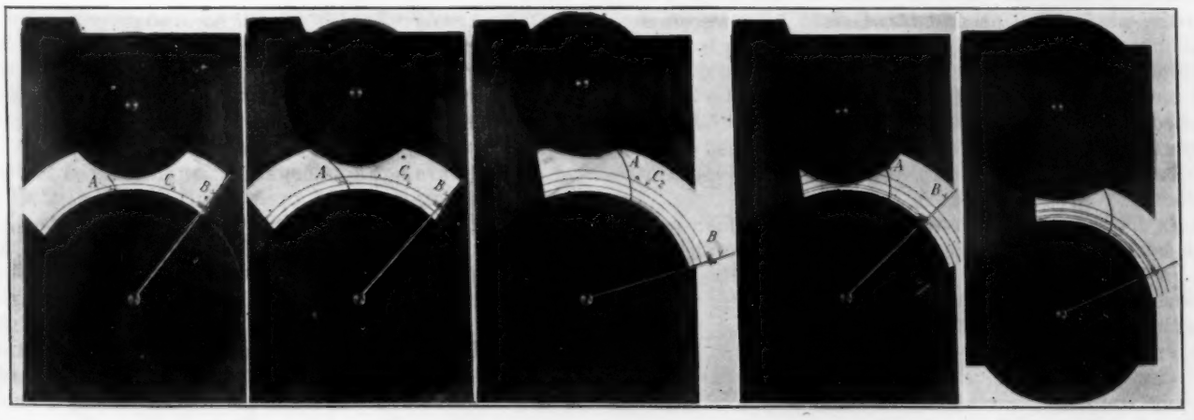


FIG. 25—DEVICE ILLUSTRATING THE SAMENESS OF THE INVOLUTE CURVE FOR ALL GEARS

will trace the involute of the larger base-circle on the sheet of paper attached to the base-circle. We use a tooth-curve of 20-deg. pressure-angle because the base-circles are located at a definite center-distance which establishes a definite pitch-diameter for each gear. With the compass-bar B we strike the pitch-circle C of the larger gear. If a similar sheet of paper were attached to the smaller gear we should also draw its pitch-diameter through the point of tape-crossing; in other words, the two pitch-circles touch at the point where the two base-circle tangents cross. So far this operation follows the well-known elementary principles of involute gearing.

Let us change the center-distance and see what will happen to the tooth-curve when we move the smaller base-circle one hole up to a center-distance of 17 in., as in the second illustration from the left. We now have a center-distance of 17 in. with the same old base-circles. This center-distance will give a pressure-angle of 27 deg. 49 min. We now draw a tooth-curve of this pressure-angle for the larger gear. The tooth-curve for the gear will have a 27-deg. 49-min. pressure-angle. You will observe that it is the same curve, only a little more of it. We now have the arc C_1, a new pitch-diameter for the larger gear, and we have a proportionate increase in the pitch-diameter of the smaller gear.

Let us increase the center-distance once more, shifting the smaller base-circle upward to the last hole, which makes the center-distance 18 in., as in the middle view. We have now a center-distance of 18 in. and can use some more of the involute curve. This is still the same old tooth-curve, but the pitch-diameter is a little farther out from the base-circle, that is, the arc C_2, of the new pitch-circle. At this pitch-diameter we have a pressure-angle of 33 deg. 21 min. Somewhere on this curve you will find any special tooth-form in which you are interested.

If we go back to a smaller center-distance than the one with which we started, by shifting the smaller base-circle down to the bottom hole, as in the first view to the right of the center, we get our old friend, the 14½-deg. pressure-angle.

If the center-distance is exactly 15.5296 in., we shall have a pressure-angle of exactly 14 deg. 30 min. You will note that we are still using the same involute curve, but we go only a little way up from the base-circle. You will readily appreciate that I could have changed the pressure-angle by changing the base-circle diameter instead of changing the pitch-diameter.

I have found that most mysteries of involute gearing dissolve when gear problems are attacked directly from first principles. I hold no brief for any particular pressure-angle; there are cases in which we recommend large pressure-angles and other cases in which we recommend small pressure-angles. In all cases you must reproduce the tooth-form accurately so that the gears finished today will mesh with those finished next week and with those finished next year. The closer you can keep the process to the elementary principles, which are based entirely on straight lines and circles, the easier it will be to reproduce any given tooth-form in quantities.

It is logical that gear-teeth should be finish-ground after heat-treatment. We should not think of letting a cam go without grinding; and every gear-tooth is a cam. It moves at a higher velocity and under greater pressure than the cams that operate the valves.

Gear-Noise

A big item in the cost of transmission production is the tearing-down and reassembling of gearboxes on account of gear-noise. This cost often extends beyond the transmission department to the chassis-assembling department and even to the finished cars after shipment. These items of cost are entirely eliminated by the finish-grinding of the gear-teeth after heat-treatment, provided, of course, that proper standards are adhered to and the gears are tested for tooth-form and spacing before assembling. In some cases it has been shown that the saving in assembling costs, inspection and rejections was greater than the additional cost of grinding, when compared with those of previous methods.

Automobile design has been seriously handicapped by the lack of a process for generating gear-teeth after hardening. This new process not only eliminates gear-noise, but the designing engineer can do things he never dared do before because hardened gears could not be made quiet. One passenger-car builder, among those who recently have adopted gear-grinding, is now working on a four-speed transmission. With four-speed transmissions, engines can be run within their most efficient range for the greater part of the time. The public now hesitates to use change-speed gears because it does not like the noise. The man whose car accelerates quickly on a 5 to 1 direct drive will be more than pleased with the acceleration he will get at 6 or 7 to 1 with a four-speed transmission. Take a list of passengar-car specifications for 1923 and check their rear-axle ratios; then figure how many revolutions the rear wheels must make in a mile and how fast the engine must run to make 30 m.p.h. There are many cars in which the engines would have to run at 4000 to 5000 r.p.m. to make the speeds that salesmen claim for them.

The grinding of gear-teeth opens up possibilities for a really high fourth-speed and a smoothness of operation in traffic that the one-speed driver never has experienced. We shall see four-speed jobs and we may see transmissions in which there is no direct drive, thus making all speeds uniformly efficient. Getting the propeller-shaft on another and a lower center permits lowering the body floor and reducing the angle of universal-joint operation.

Quiet gears also are more efficient. The improvement in fuel economy that is accomplished by using the most efficient gear-ratio under all driving conditions will more than offset any loss of power in the gears, particularly when the gears are really efficient.

Transportation cost by truck is being given more attention on a ton-mile basis than is the transportation cost of passenger cars on a passenger-per-mile basis. Four years ago 37 per cent of American motor-trucks had four-speed transmissions; today 62.2 per cent have them.

Other changes in design will be brought about by gear-tooth grinding. Transmission shafts will have to be designed so that all the gear-teeth can be reached with a grinding-wheel; cluster gears, made in one piece with the shaft, must go. The car-owner then can buy one gear without buying a whole assemblage of gears.

A few years ago our organization advocated the use of helical timing-gears in place of the spur timing-gears that were then in vogue. The reason was that the helical gears split up the errors in tooth-form and spacing, so that with a given degree of accuracy, helical gears are quieter than spur gears. The process of gear-tooth grinding that we now use has changed conditions so that it is now possible to make spur gears more accurate and it may come about that spur timing-gears with hardened and ground teeth will replace helical timing-gears and chain drives. The change from helical to spur gears can be made very easily, when spur gears are to be

ground, as the grinding process handles an odd diametrical pitch as well as any standard pitch. The diametrical pitch of spur gears will be the diametrical pitch of the helical gears multiplied by the cosine of the helix angle, thus maintaining the same number of teeth to the same center-distance.

THE DISCUSSION

QUESTION:—What time is involved per tooth or per gear?

E. J. LEES:—For taking one cut, or really one cycle, consisting of two passes of one side of the gear-tooth over the wheels, 15-tooth gear, 14.4 sec. per tooth; 17-tooth gear, 13.2 sec.; 18-tooth gear, 10.8 sec.; 21-tooth gear, 9.6 sec.; 25-tooth gear, 9.6 sec.; 29 and 31-tooth gears, 8.4 sec. This is on six to eight-pitch gears with the wheel running at 5000 ft. per min.

QUESTION:—Do you prescribe a wet or a dry grind?

GLENN MUFFLY:—A wet grind always.

QUESTION:—Is there any drawing action on account of heat?

MR. MUFFLY:—Not more so than in any other wet grinding. We grind off ordinarily only about 0.003 in. If there is more to be removed we take two cuts. It is all wet grinding, so one need not worry about taking out the hardness produced by heat-treatment.

QUESTION:—What is the cost per tooth for grinding by this process?

MR. LEES:—You have the time per tooth and you each know what the overhead is in your own plant. Today I was told by a Detroit manufacturer that he had ground 38,850 teeth on both sides, two cuts, four passes, on each side, using a No. 3850-I silicate wheel. This is equivalent to 77,700 teeth ground twice round on one side. A vitrified wheel would show a longer life. A recent change in the form of the wheel will add to these figures. The cost per wheel is about $30.

MR. MUFFLY:—One user gave a figure of $1.75 per transmission. Another said that the cost per transmission was a few cents more than the cost of the finishing cut, which was replaced by grinding, but that he made it up in the saving in the cost of assembling.

QUESTION:—Do the chatter marks from the grinding-wheels show on the testing-machine?

MR. MUFFLY:—No.

QUESTION:—How do you prevent dirt from getting between the tape and the segment?

MR. MUFFLY:—These parts are well protected from the flying particles and the direction of wheel rotation throws the particles off in the opposite direction. We have never had trouble with dirt getting under the tapes; if it should happen we should note the error on the gear-tester.

QUESTION:—Is the durability improved by grinding?

MR. MUFFLY:—Yes; the life of a gear is lengthened by having the tooth-curve correct. Ground gears not only save gasoline but they save wear-and-tear on the gear-teeth, as well as on the ear-drum.

QUESTION:—Is there much trouble with the breaking of the tapes when used with small numbers of teeth with an involute curve?

MR. MUFFLY:—They all have involute curves. The tapes last longer when wrapped round a large segment than when wrapped round a small segment. We use double tapes so that the breaking of a tape is not a serious matter. There is a great difference in tapes. The tapes that we are now using give practically no trouble. For the first two years our machines ran almost exclusively on constant-drive gears and on reverse idlers, so that we had plenty of experience on small diameters and small numbers of teeth. Much of our trouble was avoided by the application of power to the work-spindle instead of to the slide.

QUESTION:—How close must the center-distance be held?

MR. MUFFLY:—Make it ¼ in. if you wish. The center-distance makes no difference whatever with the involute principle, so long as the teeth hit each other and the next tooth comes into contact before the last one lets go. You will only be using a different part of the curve. Most of you at some time have had a pair of gears that were cut for a certain center-distance and have had to spread the center-distance a few thousandths to make the gears run freely. If the gears were supposed to have a 20-deg. pressure-angle and increasing the center-distance made the pressure-angle 20 deg. 13 min., you might have tacked your name on that particular pressure-angle. Variations in the center-distance make no difference except to increase the pressure-angle. But you must have the teeth thick enough to prevent excessive backlash; if you spread the center-distance, see that the shafts are kept parallel. Do not think, as some persons do, that shafts are parallel just because they are the same distance apart at the ends. If you take two sticks and tie them together at the ends with strings of equal length so that the sticks are parallel when in the same plane, you can twist the sticks about until they actually cross each other and still keep them the same distance apart at the ends. You must check a pair of shafts by a surface-plate to see that they are in the same plane, as well as measure to see that they are the same distance apart at the ends.

QUESTION:—Is any modification recommended?

MR. MUFFLY:—Yes, a very small amount, so small that you would call the tooth a perfect involute if it were measured by any of the older methods.

MR. LEES:—The average amount of modification is probably between 0.0002 and 0.0004 in.

QUESTION:—Does this vary with each particular design?

MR. MUFFLY:—Yes. With every pair of gears there is an individual problem as to interference, clearance, tooth distortion, rigidity of shafts and accuracy of bearings. We cannot make one rule that will fit all cases. Having tried out a transmission and tested each gear on the testing-machine, we find the exact modification and chart it, as has been explained. With this information we are able to reproduce the tooth-form absolutely, so that the gears that are cut next week and next year will run quietly with those that are cut today. We actually measure the noise in the tooth-form before the noise occurs.

QUESTION:—What amount of grinding stock should be left on gears of eight diametral pitch?

MR. LEES:—About 0.002 to 0.003 in.

MR. MUFFLY:—If the gears are roughed out accurately and the heat-treatment does not produce much distortion, we can get by with as little finish as 0.002 in. but sometimes we find that the gears are out considerably more than this and we have to take off from 0.003 to 0.005 in. to correct the teeth.

QUESTION:—Is it worthwhile to correct gears other than those of heat-treated steel by the grinding process?

MR. MUFFLY:—Yes; if you are particular about accuracy. Automobile transmission gears present the most urgent problem. To get an accurate spur gear of cast iron or of bronze it should be ground by this process.

QUESTION:—How about the time, the accuracy and the like required for grinding both sides of the tooth?

MR. MUFFLY:—We grind teeth on both sides but not at the same time. It takes twice as long to grind both sides, but it is advisable if you want real accuracy.

QUESTION:—What is the effect of cutting a gear undersize to obtain freedom of motion on the tooth-form?

MR. MUFFLY:—The effect is to give pitch-line clearance or backlash. If the gears are meshed on a lesser center-distance, the effect is to reduce the pressure-angle. We accomplish the desired result by grinding the teeth thinner, not by cutting in deeper with the wheel. A popular misinterpretation of this is seen on many blueprints. A six-pitch gear with 30 teeth has a 5-in. pitch-diameter, but the pitch-diameter is specified on blueprints as 4.998 in. or something like that. The designer means that he wants the teeth to be cut deeper so as to obtain a certain amount of backlash. It is absolutely impossible to generate a six-pitch gear with 30 teeth at any other pitch-diameter than 5 in. You may set the hob in deeper or you may grind the tooth thinner, but the pitch-diameter of the gear is determined by its velocity-ratio relative to the hob or grinding wheel. The moment you remove the gear from the machine it loses its pitch-diameter, and when you mesh it with another gear it acquires a pitch-diameter, but not necessarily the same one as that on which it was cut. The expression "cutting a gear at less than standard pitch-diameter" has been inherited from the old-style disc-type gear-cutter, which really produced a bastard tooth when the cutter was set in deeper.

QUESTION:—Does the irregularity of the rough-cut gear affect the grinding sufficiently to require more time on some gears than on others?

MR. MUFFLY:—Yes; some gears are so badly cut that we have to give them an extra cut on the grinding machine. Ordinarily, 0.003 in. is ample allowance for a grinding-finish. If the roughing machines leave greater errors than this it would pay to replace them with more accurate machines. Gear-grinding is creating a demand for single-purpose heavy-duty hobbing machines to meet this condition. The form of tooth produced by hobbing comes nearer to the true involute than that produced by other methods; consequently there is less metal to be removed by the grinding machine.

QUESTION:—What backlash can be used with ground gears?

MR. MUFFLY:—The maximum variation in the tooth spacing and the tooth contour of gears ground by our process is 0.00025 in. A quarter thousandth of backlash will take care of this provided the rest of the machine-work is accurate enough to allow such a small tolerance. Backlash has heretofore been allowed to accommodate the variations in the gear-teeth, but now you have only to provide the amount of tolerance required to match the tolerance on the center-distance and the eccentricity of the bearings.

QUESTION:—Can bevel gears be ground?

MR. MUFFLY:—There is no machine on the market for that purpose at present.

QUESTION:—Does the process of heat-treating become simpler or cheaper due to truing in the final operation?

MR. MUFFLY:—It becomes both simpler and cheaper. Some manufacturers are going to considerable additional expense in heat-treatment to hold the distortion down to the minimum. This expense can be avoided. Other manufacturers have found it impracticable to use certain steels that possess very good physical properties but do not finish smooth. Steels that may be less expensive than those used in the past can now be adopted, as the grinding machine will put a good finish on them. Some manufacturers use low-carbon steels and go to considerable expense to carburize the gears after roughing them, then finish-cut and quench them from a comparatively low temperature, to minimize the distortion. This expensive carburizing operation can be reduced or eliminated entirely by using different steel and by finish-grinding after heat-treating.

QUESTION:—Have efficiency tests been made to determine the gain made by grinding? If so, how much has the efficiency been increased over that of ordinary gears?

MR. MUFFLY:—I do not know of any extensive tests for that purpose. There is no doubt that grinding makes the gears more efficient. Irregularities that cause noise must also decrease the efficiency. In worm gears the efficiency is increased by the introduction of the tangential feed of the hob, which provides more complete generation. We have seen cases, such as those of turbine drives, in which hardened gears had considerable tooth distortion and were shorter-lived than soft gears of more accurate tooth-form. The efficiency, the quietness and the life of a gear are very closely associated.

QUESTION:—Does not variation in oil-film thickness due to the temperature and the quality of the oil more than offset the close limitation of the variations permitted with tooth-grinding?

MR. MUFFLY:—Yes; I believe this would be true except for the fact that the pressure per unit of area on transmission-gear teeth is so high as practically to eliminate the oil-film on the line of tooth contact. On gears of relatively large diameter, where the machine-work on other parts is very accurate, it would be necessary to make an allowance for the expansion of the metal itself.

QUESTION:—Would you recommend a lighter lubricant in a transmission using ground gears?

MR. MUFFLY:—Not necessarily. If the heavy lubricant were put in solely for the purpose of deadening the noise, then yes; if the heavy lubricant were put in for lubrication, then I should keep it. You know second-hand dealers have a way of taking old cars and filling them up with heavy oil with a little ground cork in the transmission and differential; it makes them run quietly for a little while.

T. J. LITLE, JR.:—That is exactly what I had in mind when I asked that question. I thought you might recommend a lighter lubricant, because it tends to become heavier with use.

MR. MUFFLY:—I should say that ground gears obviate the necessity for a heavy body to deaden the noise and enable this problem to be treated from the standpoint of lubrication only. Of course, there is a sliding action between the teeth, except at the pitch-line, and ground gears do need lubrication, but they do not make so much fuss about running out of lubricant as ordinary gears do, and they do not require a heavy oil to gum the teeth and deaden the vibration. Lighter oils may have as much lubricating value as heavy oils and therefore may be preferred.

QUESTION:—If tooth deflection must be compensated for, how can noise be eliminated under variable loads?

MR. MUFFLY:—You will never eliminate the difference in tooth deflection between a heavy load and a light load, but if you make enough modification to avoid interference under maximum load, you will also avoid interference on light and medium loads. If you take

care of the maximum load, you will be on the safe side.

QUESTION:—If a correction of profile is made to take care of the tooth deflection under load, what effect will it have when the gears are running idle?

MR. MUFFLY:—It will have the effect of giving a little additional clearance at the point of the tooth. If you have a full-depth six-pitch tooth and have made the necessary modification for tooth deflection under full load, then under a light load you will be using practically a stub-tooth gear, as the point of the tooth will not be working at all. You will merely be using a little less of the involute curve, the same as you would use on a stub-tooth gear.

QUESTION:—Referring to timing-gears, not hardened, what objection is there to swaging teeth by rolling them under pressure with a ground master-gear?

MR. MUFFLY:—It would help some by wearing off the high spots, but it would not be equal to a ground gear. This is a burnishing operation that requires a frictional contact on the surface to be burnished. At the pitch-line you have a rolling contact instead of a frictional contact, so the burnishing will not be uniform. The idea of working from a master gear was given a rap by a general foreman with whom I talked recently. He said that a certain inventor of a gear-grinding machine that uses a master gear and rack to get the relative motion was trying to sell the idea to this plant. The foreman asked, "Where did you get the master gears?" It appeared that the master gears were ground on a machine using tapes to get the relative motion. The foreman then asked, "Why not use the tape principle and make all the gears master gears?" The closer you stick to basic principles the better gears you will get. Any shop that has a cylindrical grinding machine can grind a tape segment very close to the desired diameter. Anybody can dress the wheel to a flat surface. It is by sticking to these basic principles that we keep within such narrow limits.

QUESTION:—Does the straight-edge roll on the base-circle without slippage when testing?

MR. MUFFLY:—Yes. If it slips, you will get a jump on the indicator that will look like that produced when testing a gear before grinding.

QUESTION:—Have any experiments been made to apply this method to the grinding of spiral bevel-gears?

MR. MUFFLY:—Yes; experiments, but not in a production machine.

QUESTION:—What do you consider to be the limit of index error on a transmission pinion; that is, the cumulative error?

MR. MUFFLY:—It is the tooth-to-tooth error that is important. If the tooth-to-tooth error is less than 0.00025 in., the gear will be reasonably quiet. It makes no difference whether the error is cumulative round the gear and comes back again to the starting-point, or goes up and down tooth by tooth; the effect is the same; the limit that we set on it is 0.00025 in.

QUESTION:—How do you determine the radius of the tooth-curve due to deflection by considering the variation of load on the tooth and the different elastic-limits of the materials used in gears?

MR. MUFFLY:—We do not calculate that theoretically. We take off an amount that has been found satisfactory in other transmissions and put the gear to the test. If it is quiet we stick to that form; having the testing-machine and the means for plotting the curve, we can hold our production to the desired form.

QUESTION:—What is the actual time required to grind a driving-gear of 1½-in. face, with 18 teeth, and a driven gear with 30 teeth, 7/8-in. face, both six-pitch?

MR. LEES:—For the 18-tooth gear, 3¼ min.; 4 1/4 min. for the 30-tooth gear.

QUESTION:—Do you advocate grinding both sides of the tooth?

MR. MUFFLY:—Yes.

QUESTION:—Which is the more important, the spacing or the profile?

MR. MUFFLY:—They are equally important. We have the same limit on both, 0.00025 in.

QUESTION:—Do the grinding-machines index automatically, or is each tooth indexed by the operator when it is finished?

MR. MUFFLY:—The machines index automatically from tooth to tooth, and are set to stop automatically at the end of one complete revolution; or, in case of grinding twice round the gear, at the end of two complete revolutions.

QUESTION:—What is necessary in tooling-up for a given gear besides making a special segment for the machine?

MR. MUFFLY:—Making an arbor to hold the gear; that is all, unless you have to buy a new index-plate for the number of teeth. An index-plate for a certain number of teeth can be used for all pitches. The wheel is not changed when you change from one pitch to another. The only change required in going from one pressure-angle to another is to swivel the grinding-wheel spindle to whatever pressure-angle is desired.

QUESTION:—With the correct contour and spacing, what effect has the amount of backlash on gear noise?

MR. MUFFLY:—With a constant load it will have no effect. With an intermittent load the effect will depend on the amount of backlash and the amount of variation in the load or the reversal of the load. When the load, not necessarily the direction of rotation, is reversed you will get a click. The volume of noise from this source will depend on the velocity of the load reversal, the amount of torque involved and the amount of backlash. If you are driving in one direction all the time with a constant load, the amount of backlash will make no difference. The teeth can be cut down to one-half their thickness without affecting the noise, except that you would weaken the teeth and so increase the distortion.

GEORGE E. GODDARD:—I think, perhaps, a camshaft load is meant.

MR. MUFFLY:—On a camshaft drive, you would, of course, have an intermittent load, and it would be advisable to hold the backlash down. If you can hold the center-distance accurately enough, you can, with ground gears, keep the backlash down to a point where it will produce no noticeable noise. The amount of backlash to be allowed will depend on how closely you can hold the center-distance. You could vary the center-distance at will, without affecting the involute principle, provided you vary the tooth thickness with the center-distance. If you cannot hold the center-distance accurately enough it will be necessary to grind some gears with thick teeth and some with thin teeth so as to reduce backlash by selective assembling. The only reason for holding the center-distance accurately is to hold down the backlash.

QUESTION:—Have you determined what effect the pressure-angle has on gear noise?

MR. MUFFLY:—We sometimes recommend a small pressure-angle and sometimes a large pressure-angle. If the number of teeth is large, with an intermittent load such as on a camshaft drive, I should advise a small pressure-angle, because with a large number of

teeth you will not have the interference problem, and with a small pressure-angle a given variation in the center-distance will produce less backlash. We may, therefore, say that the small pressure-angle is desirable from the standpoint of quietness, because it makes it easier to hold down the backlash. On the other hand, in automobile transmissions you have a smaller number of teeth, and the tooth load is considerably greater, in which case it is advisable to use a larger pressure-angle to avoid interference and to minimize tooth distortion. A large pressure-angle will avoid the undercutting of the pinions and will give a stronger tooth-form. In a general way, about 20 deg. is good for transmission-gears and about 14½ deg. for timing-gears.

QUESTION:—Do you have trouble with checking when grinding carburized and hardened gears?

MR. MUFFLY:—We have very little trouble, probably because our grinding-wheel generates the curve and so is not in contact with the entire side of the tooth at one time. I should say that the problems of gear-tooth grinding are the same as those of cylindrical grinding, so far as steels, coolant, heat-treatment, wheel material, loading and burning are concerned.

QUESTION:—Is checking more prevalent with some types of steel than with others?

MR. MUFFLY:—I believe it is.

QUESTION:—Please discuss the effect of modification as shown by your diagrams.

MR. MUFFLY:—Referring to Fig. 5, let us consider first the teeth on the driving gear. They will be deflected backward while under load. We can correct this by adding to the driving sides of the teeth near the point and by taking something off the rear sides of the driving teeth near the point. In other words, we give the teeth a little slant forward so that when deflected they will come back to the true involute. This can be accomplished by tilting the grinding-wheel to a slightly smaller pressure-angle when grinding the forward sides of the driving teeth, and to a slightly greater pressure-angle when grinding the rear sides of the driving teeth. In automobile transmissions, the driving gear is almost always smaller than the driven gear; and there will be a greater tooth-deflection with a small number of teeth than with a large number of teeth, because of the difference in tooth-form between the large and the small number of teeth. Consequently, more modification will be necessary on the driving gear than on the driven gear. Assuming that the tooth a_2 on the driving gear has been modified in this manner and being under load has been deflected back to its true position, the driven tooth b_2 will be deflected forward slightly, causing the tooth b_1 to lag slightly; also, the tooth a_1 on the driving gear is ground full on its leading side and, since it is not yet under load, we shall find that the teeth a_1 and b_1 engage before they should. For this reason, we slightly relieve the points of the teeth on the driven gear. This is a theory that will explain the reasons for the modifications that we have found effective in practice, rather than a rule to be applied universally to gears.

QUESTION:—How do you calculate the diameter of the base-circle for grinding the involute curve?

MR. MUFFLY:—In the first place, it is the pitch-circle that we use on the grinding machine, not the base-circle. I will, however, explain the method of calculating the base-circle diameter. Referring to Fig. 3, which shows the relation of the base-circle to the pitch-circle, you will recall that the line $b\,c$ was drawn perpendicularly to the line $a\,b$ and therefore $a\,b\,c$ is a right-angle triangle, of which we know the length of side $a\,c$, the pitch radius, and the angle $b\,c\,a$, which is equal to the pressure-angle. What we want to know is the length of the line $b\,c$, which is the base-circle radius. The rule is, to multiply the pitch radius by the cosine of the pressure-angle to get the base-circle radius; in other words, the pitch-diameter times the cosine of the pressure-angle equals the base-circle diameter.

QUESTION:—How about the effect of pitch overlap on noise?

MR. MUFFLY:—Meaning, I assume, the number of teeth in contact. The more teeth there are in contact the more there will be to share the load and to divide the deflection. As a rule the problem is easier with a large number of teeth than with a small number. We grind pinions successfully down to the smallest numbers of teeth used in automobile transmissions. It is easier to make a 30-tooth gear run quietly than it is to make a 12-tooth pinion run quietly, not only because more teeth are in contact and thus divide up the deflection, but because a larger number of teeth makes it easier to keep clear of interference.

W. R. GRISWOLD:—That is the reason for getting into odd pressure-angles?

MR. MUFFLY:—Yes; odd pressure-angles frequently are employed when it is found that the standard pressure-angle produces interference; the pressure-angle is increased just enough to avoid the interference. Odd pressure-angles can be handled with no change except tilting the grinding-wheel to a different angle. When you have a train of gears designed to be cut at different pressure-angles and to run together at some common pressure-angle between each pair, you can grind the entire train at one setting of the wheel by making the necessary changes in the segment diameters. You can grind a gear with a number of different settings and have the settings all come out alike; each change of the tape-segment diameter will bring you to some particular pressure-angle on the involute curve, and the grinding-wheel then will be set at this pressure-angle. All the gears will have the same base-circle and will employ the same circle on the gear-testing machine.

QUESTION:—What is the authority for computing the base-circle according to the rule Mr. Muffly stated?

MR. MUFFLY:—When you know the length of the hypothenuse and the angle opposite the perpendicular, you multiply the hypothenuse by the cosine of the angle to get the length of the base-line. This is a mathematical law, not a rule that I have invented. Taking this triangle, shown in Fig. 4, fitting it into the triangle $a\,b\,c$ in Fig. 5 and applying a little plane geometry, we prove that the angle $b\,c\,a$ is the same as the pressure-angle; the angle $t\,a\,b$ plus the angle $b\,a\,c$ equals one right angle, because the tangent $t\,t$ was drawn at right angles to the radius $a\,c$; the angle $b\,c\,a$ plus the angle $b\,a\,c$ is also known to equal one right-angle, since $a\,b\,c$ is a right-angle triangle; therefore, we know that the angle $t\,a\,b$ equals the angle $b\,c\,a$, thus proving that the angle $b\,c\,a$ is the same as the pressure-angle, because the angle $t\,a\,b$ is the pressure angle.

QUESTION:—Will ground non-metallic gears running with ground metallic gears give additional quietness?

MR. MUFFLY:—We have not ground any non-metallic gears. It seems that non-metallic material is unnecessary in a ground gear. It has been suggested that a hardened and ground spur-ring gear be made with a non-metallic hub; this might be worth experimenting with on a camshaft drive to deaden the vibration produced by the intermittent load.

QUESTION:—What effect does grinding have on the tone of the gear noise?

MR. MUFFLY:—We have quit specifying gear-teeth according to the tone of the noise, for it is impossible for any man to grade gears accurately by this method. We used to be able to identify different makes of car by the different tones of gear noise. The Panhard and the Mercedes had distinctive tones.

Methods of gear testing have changed. We no longer roll the gears together by hand, make optical inspections of tooth engagement or judge tooth errors by the tone of the gear noise. What we want is no noise at all, or gears that run so silently that there is not enough noise to analyze.

A demonstrator recently reported that the engineer at a certain factory had asked him to grind a set of gears on exact involute curves. When the gears were projected on the screen, the engineer said, "If those gears are not quiet, then no one can produce a quiet gear." The demonstrator maintained that they would not be quiet, and they were not. He then ground gears with slightly modified teeth, as described earlier in this discussion; they were quiet. The answer is, you want correct involute curves while the gears are under load rather than while they are on the testing machine.

The high or low-pitch sound that we had before the time of grinding disappears almost completely. The magnitude of the sound is very much decreased. Certainly the sound is more pleasant to the ear.

QUESTION:—Would not a 0.002-in. cumulative error between the first tooth and half-way round the gear give an "eccentric" sound?

MR. MUFFLY:—No; because that condition would not make the gear eccentric. An "eccentric" sound comes from the teeth meshing tightly on one side and loosely on the other side. In this case there would be a slight amount of acceleration and deceleration, but not that eccentric sound, nor the sound produced by a large tooth-to-tooth variation; there would be very little difference between the sound made by a gradual increase of 0.0001 in. per tooth and that made by a gradual decrease of 0.0001 in. per tooth. You would not have any decided click or eccentric sound if the error were uniformly distributed.

QUESTION:—Does the dressing of the grinding-wheel depend on the operator?

MR. MUFFLY:—The frequency, but not the accuracy, of the dressing lies with the operator. The wheel is not dressed during a grinding operation. One dressing is good for from one to six gears, depending on the size of the gears, the amount of metal to be removed and the material. The wheel is fed to the diamond, not the diamond to the wheel; so the dressing does not change the location of the grinding surface.

QUESTION:—Will ground front-end gears be as quiet as the best silent-chains under similar conditions of operation?

MR. MUFFLY:—They ought to be more quiet.

QUESTION:—Could the tape method of grinding be applied to cams instead of following the master cam?

MR. MUFFLY:—That could be done, but we are not grinding cams. On second thought we *are* grinding cams, for every gear-tooth is a cam, a cam that must stand up under heavy service. There are such things as involute cams but not in the valve mechanism of an automobile engine. If you use the tape method of grinding on something else than an involute cam you would wrap the tape about some other form than a circle.

QUESTION:—How could you obtain a constant velocity between a rack and the pitch-circle of a gear by a base-circle of less than the pitch-circle of the gear?

MR. MUFFLY:—The base-circle is always less than the pitch-circle. The base-circle velocity must be the same on any two mating gears and the pitch-circle velocity of the two gears must, of course, be the same. The ratio between the base-circle velocity and the pitch-circle velocity is represented by the cosine of the pressure-angle. In a rack we have only the pitch-line to consider, and the rack movement is always equal to the pitch-circle movement. On the grinding machine we get the relative movement of the rack tooth from the pitch-circle, not from the base-circle. On the testing machine we get the movement of the indicator-point by rolling a straight-edge on the base-circle. The base-circle of a gear must be smaller than the pitch-circle; otherwise there would be no pressure-angle at all.

QUESTION:—If the involute teeth slide on each other, would not the wear, in time, produce a flat straight line on the pitch-circle, and the wear of the forward flank cause noise?

MR. MUFFLY:—Involute gear-teeth do slide on one another and the frictional contact does cause wear. The wear is not concentrated on the pitch-line, however. On the contrary, we have a rolling contact at the pitch-line and the amount of the sliding motion increases each way from the pitch-line. The more nearly perfect the involute curves are, the better the finish on the teeth will be; and the harder the working surface is, the less the teeth will wear. Gears with correct tooth-curves will wear more uniformly than gears with incorrect teeth. The process of gear-tooth grinding now in use produces the most correct tooth-curves yet obtained in gear production, and consequently the gears are quieter and will stay quiet longer, because the wear is uniform.

PRACTICAL RESEARCH

WHEN one thinks of a laboratory, the natural conception is of a place where theorists work on purely scientific problems. The patience of the scientific investigator has won him many laurels, but has not gained him the support of the man in the shop who depends on the skill and speed of his hands and rule-of-thumb methods to meet any demands for increased production that may arise. Rule-of-thumb methods of manufacturing are still adhered to in many plants. There has been a decided awakening, however, on the part of the majority of American business men.

What is considered the science of yesterday is available for the business man of today, if he will but use it. One of the best ways to do this is to establish a works laboratory and place it in charge of a scientifically trained man. Briefly stated, the function of such a works laboratory is to apply scientific principles to the manufacture of the firm's product, so as to raise the standard of quality and still keep the cost at a minimum.

If placed in charge of the proper man, the laboratory should be the best paying department of a business. We have not yet attained 100-per cent efficiency in any mechanical process and we probably never will. The aim is to eliminate as much of the existing waste as possible.—A. L. Collins in *Machinery*.

THE SOCIETY'S STANDARDIZATION PROCEDURE

IT is the function of the Society's Standards Committee to formulate, if feasible, standards and recommended practices that will simplify and coordinate routine and engineering practice on all subjects assigned to it by the Council. To facilitate the work, the Standards Committee is resolved into 27 Divisions, each being representative of a particular branch of the industry.

PERSONNEL

The Standards Committee is presided over by a chairman and two vice-chairmen. Each Division has a chairman and one vice-chairman. The Standards Committee and Division chairmen are designated by the President of the Society, the other personnel of the various Divisions being appointed by the Council. In addition to the Division personnel, Subdivisions are appointed to formulate tentative reports covering important subjects that are under consideration, the Subdivision members being appointed by the Division chairmen. The Subdivision chairmen are usually members of the Divisions to which the Subdivisions report, but other Subdivision members are selected from the industries at large to assure the assistance of the best-qualified men in each particular field.

Members of the Standards Committee need not be necessarily members of the Society, such committee members being known as conferees and having all the privileges of regular committee members except that of voting. In selecting members of the Standards Committee importance is placed on obtaining men of broad experience and so far as possible familiarity with standards work. Many of them naturally are associated with the older and better-known companies, but they are selected for their personal qualifications.

INITIATION AND PROCEDURE

The assignment of subjects to the various Divisions is generally based on requests that have been received from members of the Society or the industry directly affected. Subjects are not assigned by the Council unless their standardization is considered feasible as well as desirable. Upon assignment to the proper Divisions, the various matters are studied with relation to the limiting phases within which standardization can be accomplished and the probable requirements of the industry affected. If a subject is involved, the features that the standard should embody are outlined and an approval of the outline obtained from the companies interested. The industries are then circularized for data representing current practice and suggestions for consideration by the Division members. The information is then, as a rule, referred to a Subdivision for the formulation of a tentative proposal which, when submitted, is referred to the industries for comment. The tentative proposals, together with the comments received, are then referred to the Divisions, and revised to meet all valid objections which may have been made. The Division recommendations are then printed in THE JOURNAL prior to consideration of them at the next meeting of the Standards Committee.

Division reports may be approved only by the Standards Committee at regular meetings held semi-annually or at special meetings called by direction of the Council. These meetings are open to Society members and non-members alike. The reports are discussed and may be approved as submitted or in revised form or referred back to the respective Divisions for further consideration. After Standards Committee approval the reports go to the Council and if approved are acted upon at a regular business meeting of the Society. The reports may be amended at these meetings but are usually approved as submitted. The reports are then submitted to the voting members of the Society for adoption by letter ballot, a majority of the votes cast being necessary to make the recommendations official S.A.E. Standard or Recommended Practices. The results of the letter ballot are referred to the Council, and in case a recommendation encounters several negative votes supported by sound engineering reasons, the Council may withhold its publication in the S.A.E. HANDBOOK until the reasons submitted shall have been reviewed by the Division making the recommendation.

Although the regulations provide that a majority of votes shall be necessary to approve a recommendation, a recommendation is seldom approved unless the action is practically unanimous. The reasons for this are patent, as well-founded objections to any adopted recommendation would militate against its general reduction to practice, resulting in a "paper standard" only.

The time required for the stated procedure varies from 3 months to in some cases a number of years, depending upon the conditions involved. A large amount of office work is required in corresponding with the industries and members of the Divisions, arranging meetings and keeping progress records.

S.A.E. HANDBOOK

Subsequent to the Standards Committee meeting, the revisions of the reports together with the discussions thereon are printed in the following issue of THE JOURNAL, the revised reports as approved being printed in the next issue of S.A.E. HANDBOOK data sheets. It is essential that all standards be published in a clear, concise and uniform manner. This was recognized in the beginning by the pioneer members of the Society and its Standards Committee, and the present well-known loose-leaf S.A.E. HANDBOOK has proved the wisdom of selecting this form of publication. Clear detailed drawings with tables and notes are used to set forth the standards and recommended practices. A complete set of the standards goes to all the members of the Society, including the new and revised standards issued twice a year. The complete Handbook is available to non-members of the Society and a single copy of any standard may be obtained upon request to the Society. The standards are not copyrighted, but it is expected that the Society will be given due credit for any of its data reprinted in other publications.

The procedure of revising existing standards is the same as when the subjects are originally considered. As such revisions are not published in the S.A.E. HANDBOOK until they have been approved by letter ballot of the voting members and this procedure usually takes several months, it is well for all interested to ascertain whether a standard is under revision in case production on a design involving the use of a S. A. E. Standard is contemplated. Complete information in reference to the current work of the Standards Committee is published regularly in THE JOURNAL.

CURRENT WORK OF THE STANDARDS COMMITTEE

AUTOMOTIVE DIVISIONS

AERONAUTIC

No active subjects

AGRICULTURAL POWER EQUIPMENT

Plowing Speeds
Tractor Rating
Tractor Testing Forms

ELECTRIC VEHICLE

Lamp Bulbs for Electric Vehicles
Storage Battery Tray Terminals

ISOLATED ELECTRIC LIGHTING PLANT

No subjects assigned

MOTORBOAT

Control Levers
Engine Couplings
Engine Testing Forms
Stuffing Boxes
Tachometer Drives
Trial Performance Forms

MOTORCYCLE

No subjects assigned

PASSENGER-CAR

Brake Tests
Frame Numbers

STATIONARY-ENGINE

No subjects assigned

TRUCK

Power Take-Off Shaft-Ends

PARTS AND FITTINGS DIVISIONS

AXLE AND WHEELS

Brake-Drums
Differential Gears
Solid-Tire Felloes
Wire-Wheel Spokes

BALL AND ROLLER BEARINGS

Corner Radii
Inch-Type Roller-Bearings
Medium-Heavy Ball-Bearings
Wide-Type Ball-Bearings

CHAIN

Roller Chains

ELECTRICAL EQUIPMENT

Automobile Wiring

ENGINE

Engine Numbers
Flywheel Housings
Poppet Valves
Starting-Cranks

FRAMES

Motor-Truck Frames

IRON AND STEEL

Part III, Chemical Compositions
Part IX, Heat-Treatments
Sheet Steel

LIGHTING

Bases, Sockets and Connectors
Focusing Mechanisms
Lamp Glasses
Motorboat Lighting Equipment

LUBRICANTS

Crankcase Lubricating Oils
Transmission Lubricants

NOMENCLATURE DIVISION

No subjects assigned

NON-FERROUS METALS

Wrought Non-Ferrous Alloys

PARTS AND FITTINGS

Flexible Discs
License-Plates and Brackets
Wire Mesh

PASSENGER-CAR BODY

Aluminum Molding
Aluminum Sheet
Body Nomenclature
Brass Molding
Door Hinges
Hardwood Lumber
Paints, Varnishes and Enamels
Steel Molding
Strap Loops
Upholstery Leather

RADIATOR

No subjects assigned

SCREW-THREADS

Screw-Thread Practice
Tire Valves

SPRINGS

Definitions
Leaf-Spring Nomenclature
Motor-Truck Springs
Passenger-Car Springs
Spring Specifications
Tests for Parallelism of Spring-Eyes

STORAGE BATTERY

No subjects assigned

TRANSMISSION

Clutch Housings
Transmission Tire-Pump Mounting

New Principles in Rotative Balance

By Amos F. Moyer[1]

Minneapolis Section Paper *Illustrated with* Photograph

FOLLOWING the presentation of this paper, written discussion was submitted to which the author was given an opportunity to reply. The discussion and the reply are printed herewith, with the understanding that the duty of The Journal has now been performed and that this discussion is thereby closed. For the convenience of the members, an abstract of the paper is presented also, together with a reference to the text and illustrations already published.

ABSTRACT

WITH the advent of high-speed machinery, the ordinary methods of rotative balancing were found insufficient. Rotative bodies that had been given the most careful static or standing balance would vibrate seriously when running, because of an unbalanced couple consisting of two quantities of equal magnitude on opposite sides of, but displaced from each other along, the axis. Thus, a second consideration in rotative balance, called dynamic or running balance, was introduced.

Until the invention of the balancing machine that the author describes, there were no means for measuring directly the resultants for the two separate ends of a rotative body, but now these quantities can be measured directly and located without the necessity of separating the standing from the running balance. The new principles are demonstrated mathematically with the aid of diagrams, the balancing machine is illustrated and described, and comments are made to afford a correct conception of the subject of balance. [Printed in the October, 1922, issue of The Journal.]

THE DISCUSSION

F. Hymans[2]:—With reference to the paper entitled New Principles in Rotative Balance, wherein A. F. Moyer describes a balancing machine invented by Dr. B. L. Newkirk, the object is to inquire into the processes employed in that machine and to refer to their novelty, for which extravagant claims are made. According to the paper, the novelties are (*a*) an alleged new principle, by inference the discovery of Dr. B. L. Newkirk, that one, and only one, correction is required in each of two arbitrary planes of revolution to eliminate the lack of balance in a body; and (*b*) a machine employing this principle and wherein no distinction is made between standing and running balance.

As to the novelty of the principle, I quote from the English translation of Stodola[3]: "Complete mass-balance can be obtained in the case of rotation about a fixed axis by the addition of two suitable masses in two otherwise arbitrary planes at right angles to this axis." Stodola is surely no obscure authority and, as his book appeared 17 years ago, the claim as to the novelty of the principle cannot very well be maintained.

Regarding the second point, Fig. 10 is a photograph of a turbine rotor in the process of balancing on one of the Akimoff heavy-duty balancing machines, which is made in capacities up to 150,000 lb. This type of machine employs the principle announced as new by Mr. Moyer. It does not distinguish between static and dynamic balance, and only two corrections are made each in a plane at right angles to the shaft. In the older types, the body had to be reversed exactly as in the Newkirk machine. In the later types, two vibrating supports are provided one of which is locked at a time. The Akimoff machine has found a wide distribution in this country and has been on the market since 1917. Thus there is in the Newkirk machine neither a new principle nor is he the first to apply it.

The paper describes a method for locating the axial plane of the required corrections on the body. Mr. Moyer does not say that the results of this method are only approximate. It requires the measuring of two amplitudes, and it is pointed out below that very slight errors in the observations lead to gross errors in the desired location of the axial plane of correction.

Many years ago Norton devised the so-called high-spot method, the results of which are more accurate than the Newkirk method. The high-spot method has the advantage that no observations or calculations on a slide-rule have to be made by the operator. Besides, the result of Newkirk's observations and calculations is an angle; namely, the angle locating the axial plane of correction with reference to an eccentric weight. But it does not inform the operator whether this angle should be laid off to the right or to the left of the eccentric weight, and another trial run is required to decide this question.

Newkirk does not lay off the plane of corrections on the work in accordance with the result of his calculations as he might do if the method really were one of precision. No, he provides the means to test them; he adjusts and readjusts these means until by experimentation, and by nothing else, he locates the plane of correction. These means help him to determine another element, which his previous calculations do not give; namely, the *amount* of the required correction. The means referred to are a weight the angular and radial positions of which, with reference to the work, can be adjusted at will. The first to employ it in an organized manner on balancing machines is N. W. Akimoff.

Furthermore, the Newkirk balancing machine is arranged so that the oscillations of the work are of one degree of freedom, which again is copied from Mr. Akimoff. The Newkirk machine requires that the body in its original and reversed positions be placed on the machine so that the two planes in which corrections are to be made comprise in each test the axis around which the body oscillates. This is the only point in which it differs from the heavy-duty Akimoff machine; it facilitates slightly the required calculations. On the other hand, this feature severely restricts the field of application of the Newkirk machine. It is limited to bodies approximately the same end-for-end, and the cradle-like construction makes it unsuitable for long and heavy bodies.

Comparing the machines that distinguish between static and dynamic balance, also the invention of Mr. Akimoff, with the Newkirk machine, let us consider the

[1] M.S.A.E.—Chief engineer, Precision Balancing Machine Co., Minneapolis, and consulting research engineer.
[2] Vibration Specialty Co., Philadelphia.
[3] See Steam Turbines, Stodola, p. 174.

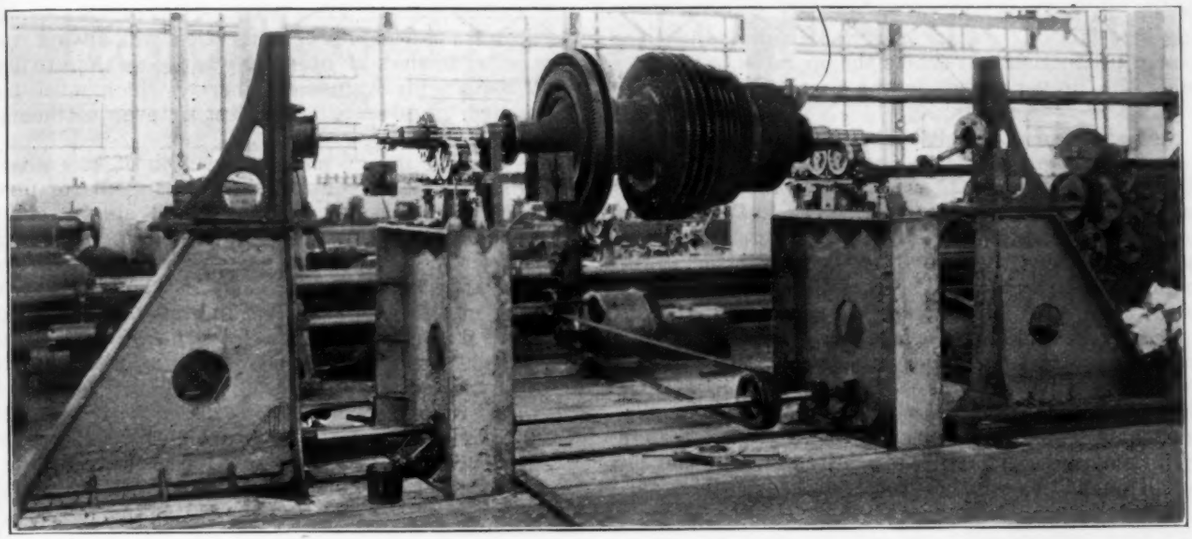


FIG. 10—BALANCING A TURBINE ROTOR

balancing of crankshafts. In the Newkirk machine we must select the webs, and set-up the machine accordingly, at which corrections are to be made *before* we know the state of unbalance of the body. Further, for production, the machine must be set-up once and for all and corrections must therefore *always* be made at the *same* webs, *no matter whether the particular state of unbalance in a given case makes these webs the most suitable.* It is this inflexibility that is the disadvantage of the Newkirk machine. It can, for example, so happen that the state of unbalance is such that the required correction lies outside of the metal of the particular web to which it should be applied; or, it can happen that the required correction is so large that if applied to the web it would weaken it seriously. The machines that distinguish between static and dynamic balance are free from this inflexibility. The states of static and dynamic balance are ascertained *first*, leaving the operator free to correct for each kind of unbalance *at any webs that are most suitable for the purpose.*

Under the heading Misconceptions of Balance, Mr. Moyer comes to the conclusion that a body balanced at any one speed is balanced at all speeds. This, of course, is a cardinal truth, and is very handy to justify balancing at a speed that is most convenient for the particular type of machine. For the approximate location of the axial plane of the required correction, Newkirk reads the amplitude of oscillations with the body alone, and then of the body in combination with an eccentric weight. From the ratio of these amplitudes, the angle locating the required plane with reference to the axial plane of the eccentric weight, whether to the right or left of it only another experiment will tell, is determined. Suppose the first reading is 20 and the second 38; then, the ratio is 1.9 and, on the chart, Fig. 6 of the paper, the corresponding angle is 140 deg., very nearly. If, however, the second reading had been 40, the ratio would have been 2 and the angle 180 deg. Thus an error in the second readings of 2 in 40, or 5 per cent, makes a difference of not less than 40 deg. in the location of the desired plane of correction; and, if there is to be in this method the faintest resemblance of precision, the amplitudes must be read with a very high degree of accuracy. No doubt a slow speed of about 100 to 110 r.p.m., such as Mr. Moyer recommends, is more suited to this purpose than a high speed.

The speed at which the work is to be balanced should not be subordinated to the convenience of a method or of a machine. In a balancing machine, we locate and measure centrifugal forces and nothing else. The larger these are, the more completely and accurately can we measure them and eliminate them. Therefore, the speed at which a body is to be balanced should be comparatively high, materially higher than 100 or 110 r.p.m. for a crankshaft. Balancing at double this speed costs no more, and there is no reason to be satisfied with a residue of 0.2 oz-in. static, or its equivalent in dynamic unbalance when, with the same labor and expense, we can come still nearer to the ideal. Of course, the centrifugal forces are proportional to the square of the velocity of rotation and the light, cheap structure of the Newkirk machine, consisting of rods or tubes clamped together, would not have the required rigidity for balancing at high speed.

A. F. MOYER:—In reply to the comments of Mr. Hymans, I must affirm that there is no statement in my papers which cannot be substantiated and, therefore, nothing to retract. Idle dispute avails nothing and, unless constructive criticism can be offered, there would seem to be little need for discussion. The particular advantages of the Newkirk system lie in precise determinations systematically laid off and applied on the work, both quantity and position being determined by measurement without experimentation or involved calculation. These results are consistently maintained in production in a routine manner successfully carried out by a good average workman. The degree of accuracy obtained by this machine is as fine as commercial applications can feasibly be made, and the rapidity of measurement is far greater than possible by any means of experimentation, including both quantity and angular position.

In comparing angular determinations, the shortcomings of the so-called high-spot method are too old and too well-known to need repetition here, but they include, besides lesser evils, an entire absence of quantity indications and the possibility of entirely false indications, causing wrong applications to be made at one end. Actually, the error in angle claimed by Mr. Hymans is never retained, because a redetermination is effected by an observation at the last position, which results in high accuracy, since the true angle is then small and an error in reading has only a much diminished effect. Whether

the angle is to the right or to the left is determined quickly by trial and, in many classes of manufacture, the process of production will enable the operator to turn the angle in the proper direction the first time on 90 per cent of his measurements.

In the balancing of crankshafts, the objections offered are of no consequence because one can make applications on other webs of the shaft, and the allowances for doing so are no more complicated than the so-called free manner of correction for each kind of balance, an unnecessary distinction that must always be employed with the static-dynamic type of machine. The particular advantages of the Newkirk system, in most directly laying off and applying the corrections on the work can, with proper allowances, be retained and fully realized. It is possible to insure that all corrections will fall within the webs at which they can be applied most easily and systematically, and will never weaken the member. Never more than four points of correction will be required and, by the cut meter, all quantities will be predetermined without special calculation or experiment. On certain types of crankshaft, two points of correction will always suffice. It is better to show an operator what to do than to depend upon his intelligent use of liberty, which must be accompanied by advanced judgment or even mathematical skill.

The detailed design and construction of this precision machine provides a considerable adjustment for unequal end-for-end dimensions and, as I have shown, only one of the planes of measurement needs necessarily to be placed over the pivots; this permits one end of the work to be of any desired excess length, so long as it will go into the machine at all. The lightness of construction employed is far from cheap, and is based upon sufficient reasons to meet the approval of authoritative designers and builders of machine tools, a leading firm of which has taken over the manufacture. As to the charges of copying, imitation and the like, I reply that Mr. Hymans is mistaken as to the identity of the persons first to use the features prominently referred to.

EXPORTS

DESPITE the enormous volume of American manufactures, except in special lines, this Country is not foremost as an exporter of industrial products. Great Britain is still first in export trade in manufactures. Outwardly, the conditions surrounding the development of industry in the United States do not appear to differ greatly from the influences that have conditioned the development of manufactures in Europe. Fundamental differences nevertheless exist. Evidence of them is found in the fact that, in the main, American manufacturers produce for domestic demand, while European industries are heavily dependent on export business.

Despite the enormous production of iron and steel the United States exports only about 6 per cent of the total product, machinery excluded. Before the war Germany exported about one-third of all the iron and steel produced in the country, and in 1922 about 30 per cent. Prior to 1914 the United Kingdom ordinarily exported about half of the product of its blast furnaces and steel mills, and last year it exported 58 per cent. The United States exports between 5 and 10 per cent of all cotton goods made here. The mills of the United Kingdom prior to 1914 exported about four-fifths of their entire product. Exports of woolen and worsted textiles from the United States are negligble. British exports on a pre-war basis were about 40 per cent of the total output. Only about 2 per cent of the boots and shoes made in the United States was exported in 1922; and, out of a total production of 2,577,000 automobiles and motor trucks, exports were but 79,000 or 3 per cent.

The statement has been made that the foreign trade of Great Britain in pre-war days was calculated at about 25 per cent of its domestic trade. The export market is probably somewhat less important to Germany, but the profitable operation of German industry nevertheless depends upon it; and the same is true of the industries of the Netherlands, of Italy in so far as Italy is an industrialized country; of the major industries of France, and of the industrialized areas of Austria and the Succession States. The industries of Belgium are of the extreme export type. It has been estimated that in normal times the Belgium glass industry must export 95 per cent of its output; the bottle, goblet and cut glass industries 70 per cent; the zinc industry 80 per cent; the steel industry 66 per cent; the flax-spinning industry 80 per cent; and the match industry 64 per cent.

This difference in the relative importance of export trade to the manufacturing industries of the United States and of Europe has existed almost from the beginning of the development of the factory system in its present sense. In Europe modern industry was superimposed upon countries already fairly mature. Fields had long been tilled. Coal was new as a source of power, but metal mines had been exploited for hundreds of years. In England and in many parts of the Continent, supplies of timber were becoming insufficient for the needs of the people. After the introduction of power spinning and weaving machinery, the use of coal as fuel, with the consequent growth of modern smelting methods and the development of numberless mechanical devices to do the work that had theretofore been done by human hands, it was possible for a time for the European countries to depend primarily upon their own natural resources and their own markets, but this condition did not long prevail. Another circumstance of considerable importance in its effect both on the consuming power of the European market and on methods of production is that before the coming of modern industry, centuries had already stabilized social customs, stratified society and fixed the habits of life of the people.

The manufacturing industries of the United States have developed with the Country. At the same period when the United States, along with Europe, was making its transition from the household and handicraft stages of industry it was also making its transition from the pioneer stage of settlement to an established community. The change was complete. Material, political and social surroundings altered coincidentally with the growth of manufactures. The minds of the people turned away from Europe and toward the West.

Important factors in the sale of American machinery abroad are developments of the principle of interchangeable parts and of the American service systems. These methods are the direct outgrowth of conditions in the United States. Large-scale production tends inevitably to standardization and ultimately to a high degree of interchangeability.—E. M. Miller, National Bank of Commerce.

Reports of Divisions to Standards Committee

THE following 13 Division reports of the automotive and parts and materials divisions of the Standards Committee will be presented for approval at the Standards Committee Meeting on Tuesday, June 19, at 11 a.m. in the Ball Room of the Essex and Sussex, at Spring Lake, N. J., this being the first day of the Summer meeting of the Society.

The reports are printed in this issue of THE JOURNAL to allow sufficient time for Society members and others to study the reports and prepare comments and suggestions for consideration at the meeting which will, as usual, be in the nature of a public hearing. Although only members of the Standards Committee may vote on the adoption of the reports, discussion is invited from everyone, whether connected with the engineering, production or servicing branches of the industry, interested in the adoption in practice of the standards proposed. The recommendations of the Divisions do not necessarily apply to present practice, although they are based to a large extent on present practice. They are intended to be followed by the various industries to which they are applicable when changes in design or production make it economically possible to do so. The general adoption in practice of a given recommendation may be a matter of months or years, depending upon the conditions involved.

A list of the several subjects before the Standards Committee is given on p. 561 of this issue. The detailed procedure followed by the Standards Committee is outlined on p. 560.

AGRICULTURAL POWER EQUIPMENT DIVISION REPORT

Division Personnel

C. B. Rose, *Chairman*	Moline Plow Co.
A. W. Scarratt, *Vice-Chairman*	Minneapolis Steel & Machinery Co.
J. B. Bartholomew	Avery Co.
C. E. Frudden	Hart-Parr Co.
A. H. Gilbert	Rock Island Plow Co.
R. O. Hendrickson	J. I. Case Plow Works Co.
P. E. Holt	Holt Mfg. Co.
John Mainland	Advance-Rumely Co.
M. B. Morgan	Timken-Detroit Axle Co.
J. F. M. Patitz	Allis-Chalmers Mfg. Co.
O. W. Sjogren	University of Nebraska
L. W. Witry	Waterloo Gasoline Engine Co.
G. A. Young	Purdue University
O. W. Young	Hyatt Roller Bearing Co.
O. B. Zimmerman	International Harvester Co.

TRACTOR BELTS AND PULLEYS

Proposed S. A. E. Recommended Practice

During the last year the Agricultural Power Equipment Division, through a Subdivision of which O. B. Zimmerman of the International Harvester Co. is chairman, has been working on the standardization of tractor driving-belts, which had been urged by both manufacturers and users. The specifications originally proposed by the Subdivision have been extensively revised as a result of several meetings at which manufacturers of canvas and rubber belting were represented. The specifications finally developed meet with the general approval of the belting manufacturers as well as the tractor builders. Although some five-ply belts are used in greater widths than specified in the report, it is recognized that to be of the most value the specifications should specify only those sizes most extensively used and absolutely necessary for proper operation under different conditions of various equipments.

Therefore the Agricultural Power Equipment Division recommends for adoption as S. A. E. Recommended Practice the accompanying specifications for tractor driving-belts.

L. W. Arny, secretary of the Leather Belting Exchange, who attended the Subdivision and Division meetings at which this subject was considered, has been appointed a member of the Subdivision to assist in preparing similar specifications for tractor leather driving-belts.

SPECIFICATIONS FOR TRACTOR ENDLESS DRIVING-BELTS

For farm tractors, new endless belts of either canvas or rubber shall measure the full taped and specified length without allowance being made for the splice. This length shall be the single stock-length and correct to within tolerances of plus or minus 0.25 per cent to take care of reasonable shrinkage or stretching in manufacture and changes due to atmospheric conditions.

All belts shall be marked to indicate the pulley side and the preferred direction of running.

TABLE 1—DIMENSIONS AND RATINGS OF CANVAS AND RUBBER BELTS

Belt Width, In.	Number of Plies	Belt Length, Ft. ± 0.25 Per Cent	Approximate Horsepower Rating[1]
5	4	75	18
6	4	50, 75, 100	22
7	4	100, 125	26
8	4	125, 150	30
8	5	125, 150	37
9	5	160	42

[1]The approximate horsepower rating is based on a belt speed of 3000 ft. per min. Belts should be operated in service at one of the S. A. E. Standard belt-speeds.

The 150 and the 160-ft. belts 8 and 9 in. wide respectively are necessary for steam tractors to conform to fire prevention laws in some States and in Canada.

PULLEY DIAMETERS

The driven pulley diameters shall be not less than 7 in. for four-ply and 10 in. for five-ply belts and should be preferably as large as practical conditions permit. To insure good traction and long life, thinner and wider belts should be chosen in preference to thicker and narrower belts.

CANVAS BELTING

Canvas belts shall be made of long fiber belt-duck free from defects and shall weigh not less than 32 oz. per linear yd. 36 in. wide, or an equivalent weight for different widths, when corrected to a basis of 6-per cent moisture.

Belts shall be well stitched with the stitching spaced not more than 9/32 in. apart across the belt and the edges and laps double-stitched with sewing twine of a quality equal to the long-fiber belt-duck.

Canvas belts shall be thoroughly water-proofed by gum, oil or paint that will not injure the fabric and will maintain the belts in a pliable condition so as to furnish good traction throughout normal changes due to wear, temperature and moisture.

RUBBER BELTING

Rubber belts shall contain long-fiber belt-duck free from defects and shall weigh not less than 32 oz. per linear yd. 42 in. wide when corrected to a basis of 6-per cent moisture.

In folding the canvas, the seaming strip shall be not more than one-third of the belt width from the edge of the belt to avoid the crowned center of the pulley.

Rubber belts shall be friction-surfaced and the duck shall be thoroughly impregnated with a good grade of rubber.

Rubber belts shall be stitched, except at the splice, with only such stitching as is necessary in good manufacturing practice.

The several plies shall be thoroughly cemented together with first-class rubber compound, making adhesion between the plies of the duck sufficient to withstand the following test:

> A strip 1 in. wide shall be cut crosswise or longitudinally from the belt and suspended vertically. A ply shall be stripped down and a 16-lb. weight fastened to it. This weight shall not cause a separation of the plies at a greater rate than 1 in. per min.

AXLE AND WHEELS DIVISION REPORT

Division Personnel

C. C. Carlton, *Chairman*	Motor Wheel Corporation
C. S. Dahlquist, *Vice-Chairman*	Cleveland
R. S. Begg	Jordan Motor Car Co., Inc.
L. R. Buckendale	Timken-Detroit Axle Co.
T. V. Buckwalter	Timken Roller Bearing Co.
R. J. Burrows	Clark Equipment Co.
L. W. Close	Bock Bearing Co.
J. Coapman	Russel Motor Axle Co.
H. E. Derr	International Harvester Co.
G. W. Dunham	Savage Arms Corporation
F. W. Gurney	Gurney Ball Bearing Co.
F. P. Hall, Jr.	Salisbury Axle Co., Inc.
G. W. Harper	Columbia Axle Co.
G. L. Lavery	West Steel Casting Co. Tire and Rim Association
A. M. Laycock	Waukesha Motor Co. Detroit Steel Products Co.
H. V. Ludwick	Budd Wheel Corporation
C. T. Myers	Consulting Engineer
O. J. Rohde	Wire Wheel Corporation of America
F. A. Shuler	Shuler Axle Co.
F. S. Spring	Courier Motors Co.

FRONT-WHEEL MOUNTINGS

(Proposed Extension of S.A.E. Recommended Practice)

As a result of further consideration, the Axle and Wheels Division recommends the passenger-car front-wheel dimensions given in Table 2 for adoption as an extension of the present S.A.E. Recommended Practice for Front-Axle Hubs, page F1b of the S.A.E. HANDBOOK. These dimensions will complete the present recommended practice for inch-size taper roller bearing front-axle hubs for passenger-cars and motor trucks.

[A meeting of the Axle and Wheels Division will be held on the morning of June 19 to review the report herein submitted, as certain dimensions have been questioned. Any revisions decided upon at that time will be submitted at the afternoon session of the Standards Committee Meeting.]

TABLE 2—PASSENGER-CAR FRONT-WHEEL WOOD HUBS

Hub Size	Outside Diameter of Hub	Distance Between Flanges	Flange Diameter	Flange Fillet-Radius	Bolt-Circle Diameter	No. of Bolts	Bolt Size[1]	Hub-Cap Thread
R0	2.1830 2.1860	1¼	6	3/8	5	6	3/8	2 1/16-24
R1	3.0625 3.0655	1¼	7	¼	5¾	12	7/16	2 7/16-16
R2	3.5000 3.5030	1⅜	7¼	¼	6	12	7/16	2 7/16-16
R3	3.6875 3.6905	1½	7⅝	3/8	6¼	12	7/16	3 -16
R4	3.8125 3.8155	1¾	8	3/8	6¼	12	7/16	3 3/16-16

[1]Machine screw bolts.
Note: The data in the table apply to wheels with wood or steel felloes, that is to all wheels having wood hubs.

TENON HOLES FOR PNEUMATIC-TIRE FELLOES

(Proposed S.A.E. Recommended Practice)

As a result of the increasing use of wood wheels with steel felloes, the Axle and Wheels Division recommends the adoption as S.A.E. Recommended Practice of the following table of tenon-hole sizes for steel felloes.

TABLE 3—TENON-HOLE DIAMETERS FOR PNEUMATIC TIRE WOOD WHEELS WITH STEEL FELLOES

Nominal Tire Cross-Section Diameter, In.	Spoke Size, In.	Tenon-Hole Diameter, In.
3½ or 4	1¼	½
4	1⅜	5/8
4½	1½	5/8
5	1¾	¾

The dimensions proposed are used extensively at the present time, the recommendation being submitted for the purpose of recognizing what is considered by the industry to be standard. Tenon-hole diameters have not been recommended for wheels carrying larger than 5-in. rims, as the steel felloe is not used on the larger sizes.

BALL AND ROLLER BEARINGS DIVISION REPORT

Division Personnel

F. W. Gurney, *Chairman*	Gurney Ball Bearing Co.
T. V. Buckwalter, *Vice-Chairman*	Timken Roller Bearing Co.
J. T. R. Bell	Rollway Bearing Co., Inc.
G. R. Bott	Norma Co. of America
H. E. Brunner	S. K. F. Industries, Inc.
E. R. Carter, Jr.	Fafnir Bearing Co.
D. F. Chambers	Bearings Co. of America
L. W. Close	Bock Bearing Co.
L. A. Cummings	Standard Steel & Bearings, Inc.
G. W. Dunham	Savage Arms Corporation
F. G. Hughes	New Departure Mfg. Co.
G. L. Miller	Gilliam Mfg. Co.
R. G. Schaffner	Bower Roller Bearing Co.
W. R. Strickland	Cadillac Motor Car Co.
R. E. Wells	Hyatt Roller Bearing Co.
H. Wickland	U. S. Ball Bearing Mfg. Co.

METRIC-TYPE THRUST BALL-BEARINGS

(Proposed Extension of S.A.E. Standard)

The Ball and Roller Bearings Division recommends that the present S.A.E. Standard for Metric-Type Thrust Ball-Bearings, pp. C39, C40, C41, C42 of the S.A.E. HANDBOOK, which specifies tolerances only, be extended by the addition of the definite boundary dimensions which were printed on pp. 531, 532, 533 and 534 of the December, 1922, issue of THE JOURNAL.

The boundary dimensions, which were referred back to the Ball and Roller Bearings Division by the Standards Committee in January, 1923, are resubmitted for approval to recognize the existing practice of four

TABLE 4—LIGHT-SERIES METRIC ROLLER-BEARING DIMENSIONS

Bearing No.	Inside Diameter			Outside Diameter			Width, In. Plus or Minus 0.020	Corner Radius Cups ½ in. Cones	Eccentricity Tolerances of Races, In.	
	Mm.	In.	Tolerances in Inches Minus 0.0000 Plus	Mm.	In.	Tolerances in Inches Minus 0.0000 Plus			Inner	Outer
L 04	20	0.78740	0.0010	47	1.85040	0.0010	3/4	1/32	0.0010	0.0012
L 05	25	0.98425	0.0010	52	2.04725	0.0010	3/4	1/32	0.0010	0.0012
L 06	30	1.18110	0.0010	62	2.44095	0.0010	3/4	1/32	0.0010	0.0012
L 07	35	1.37795	0.0010	72	2.83465	0.0010	7/8	1/32	0.0010	0.0012
L 08	40	1.57481	0.0010	80	3.14962	0.0010	1	1/32	0.0010	0.0012
L 09	45	1.77166	0.0010	85	3.34647	0.0010	1	1/32	0.0010	0.0016
L 10	50	1.96851	0.0010	90	3.54332	0.0010	1	1/32	0.0010	0.0016
L 11	55	2.16536	0.0010	100	3.93702	0.0010	1 1/16	1/32	0.0010	0.0016
L 12	60	2.36221	0.0010	110	4.33072	0.0010	1 3/16	1/32	0.0010	0.0016
L 13	65	2.55906	0.0010	120	4.72443	0.0010	1 3/16	1/32	0.0010	0.0016
L 14	70	2.75591	0.0010	125	4.92128	0.0010	1 1/16	1/32	0.0010	0.0016
L 15	75	2.95277	0.0010	130	5.11813	0.0010	1 1/16	1/32	0.0010	0.0016
L 16	80	3.14962	0.0010	140	5.51183	0.0010	1 5/16	3/64	0.0012	0.0018
L 17	85	3.34647	0.0012	150	5.90554	0.0012	1 3/4	3/64	0.0012	0.0018
L 18	90	3.54332	0.0012	160	6.29924	0.0012	2	3/64	0.0012	0.0018
L 19	95	3.74107	0.0012	170	6.69294	0.0012	2 1/16	3/64	0.0012	0.0018
L 20	100	3.93702	0.0012	180	7.08664	0.0012	2 3/16	3/64	0.0012	0.0018
L 21	105	4.13387	0.0012	190	7.48035	0.0012	2 1/16	3/64	0.0012	0.0018
L 22	110	4.33072	0.0012	200	7.87405	0.0012	2 3/4	3/64	0.0012	0.0018

American manufacturers that are producing metric-type thrust ball-bearings at the present time according to the standards proposed.

Standards covering inch-type thrust ball-bearings were formulated by the Division in 1917 and were adopted by the Society the same year. They are printed on pp. C34 to C39 of the S.A.E. HANDBOOK.

METRIC-TYPE ROLLER BEARINGS

(Proposed Revision of S.A.E. Standards)

The Ball and Roller Bearings Division recommends that the present S.A.E. Standards for Metric-Type Roller Bearings, pp. C43 and C44 of the S.A.E. HANDBOOK, be revised to conform to the dimensions given in Tables 4 and 5.

As revised, the inside and the outside diameters correspond to the inside and the outside diameters for the same sizes of annular ball bearings for the light and the medium series, pp. C26 and C28 of the S.A.E. HANDBOOK. The widths are in accord with the widths of the wide-type annular ball-bearings, p. C31 of the S.A.E. HANDBOOK. The serial designations have been revised, letters "L" and "M", standing for "Light" and "Medium", being prefixed to numbers indicating one-fifth of the inside diameters in millimeters. The tolerances for the inside and the outside diameters and the widths conform to those for inch-type roller bearings rather than following those of the ball-bearings because of the inherent difference in the character of the bearings and the methods of installation.

In recommending these revisions, the Division feels that there is sufficient demand for standard metric-type roller bearings that are interchangeable with wide or double-row type ball-bearings to warrant retaining the present standards, especially as this type bearing is manufactured in Europe to a certain extent. The Roller Bearing Subdivision, which originated the above recommendation, is working on the standardization of inch-type roller bearings. Although no real progress has been made to date, it is recognized the standard inch-type roller bearings are of extreme importance to the industry owing to their extensive use. The metric-type

TABLE 5—MEDIUM-SERIES METRIC ROLLER-BEARING DIMENSIONS

Bearing No.	Inside Diameter			Outside Diameter			Width, In. Plus or Minus 0.020	Corner Radius Cups ½ in. Cones	Eccentricity Tolerances of Races, In.	
	Mm.	In.	Tolerances in Inches Minus 0.0000 Plus	Mm.	In.	Tolerances in Inches Minus 0.0000 Plus			Inner	Outer
M04	20	0.78740	0.0010	52	2.04725	0.0010	7/8	1/32	0.0010	0.0012
M05	25	0.98425	0.0010	62	2.44095	0.0010	1	1/32	0.0010	0.0012
M06	30	1.18110	0.0010	72	2.83465	0.0010	1 1/16	1/32	0.0010	0.0012
M07	35	1.37795	0.0010	80	3.14962	0.0010	1 3/16	1/32	0.0010	0.0012
M08	40	1.57481	0.0010	90	3.54332	0.0010	1 5/16	1/32	0.0010	0.0012
M09	45	1.77166	0.0010	100	3.93702	0.0010	1 7/16	1/32	0.0010	0.0016
M10	50	1.96851	0.0010	110	4.33072	0.0010	1 3/4	1/32	0.0010	0.0016
M11	55	2.16536	0.0010	120	4.72443	0.0010	1 13/16	1/32	0.0010	0.0016
M12	60	2.36221	0.0010	130	5.11813	0.0010	2 1/16	1/32	0.0010	0.0016
M13	65	2.55906	0.0010	140	5.51183	0.0010	2 1/16	1/32	0.0010	0.0016
M14	70	2.75591	0.0010	150	5.90554	0.0012	2 1/16	1/32	0.0010	0.0016
M15	75	2.95277	0.0010	160	6.29924	0.0012	2 1/16	1/32	0.0010	0.0016
M16	80	3.14962	0.0010	170	6.69294	0.0012	2 1/16	3/64	0.0012	0.0018
M17	85	3.34647	0.0012	180	7.08664	0.0012	2 1/16	3/64	0.0012	0.0018
M18	90	3.54332	0.0012	190	7.48035	0.0012	2 1/16	3/64	0.0012	0.0018
M19	95	3.74017	0.0012	200	7.87405	0.0012	3 1/16	3/64	0.0012	0.0018
M20	100	3.93702	0.0012	215	8.46460	0.0012	3 1/4	3/64	0.0012	0.0018
M21	105	4.13387	0.0012	225	8.85830	0.0012	3 1/16	3/64	0.0012	0.0018
M22	110	4.33072	0.0012	240	9.44886	0.0012	3 5/8	3/64	0.0012	0.0018

roller bearing standards are considered necessary, however, for those manufacturers using this type of bearing.

Shaft and Housing Fits and Tolerances for Ball Bearings

(Proposed Cancellation of General Information)

The ball-bearing manufacturers have agreed that it is not practicable to recommend shaft and housing fits and tolerances for ball-bearings because each application usually depends upon particular conditions which must be met individually. The Ball and Roller Bearings Division therefore recommends that the present general information published on p. C33d of the S.A.E. Handbook be cancelled.

ELECTRICAL EQUIPMENT DIVISION REPORT

Division Personnel

F. W. Andrew, *Chairman*	Eisemann Magneto Corporation
T. L. Lee, *Vice-Chairman*	North East Electric Co.
C. R. Alling	Underwriters' Laboratories
Azel Ames	Kerite Insulated Wire & Cable Co.
W. A. Chryst	Dayton Engineering Laboratories Co.
S. F. Evelyn	Continental Motors Corporation
C. F. Gilchrist	Electric Auto-Lite Corporation
W. S. Haggott	Packard Electric Co.
F. C. Kroeger	Remy Electric Co.
B. M. Leece	Leece-Neville Co.
A. D. T. Libby	Splitdorf Electrical Co.
W. P. Loudon	Westinghouse Electric & Mfg. Co.
Charles Marcus	Bijur Motor Appliance Co.
Ernest Wooler	Cleveland Automobile Co.

Magnet Wire

(Proposed S.A.E. Standard)

The Electrical Equipment Division recommends the adoption of the accompanying magnet wire specifications as S.A.E. Standard. These specifications were formulated by a Subdivision, the personnel of which is as follows:

Chas. Marcus, *Chairman*,	Bijur Motor Appliance Co.
J. A. Harvey	Harvey Mfg. Co.
C. F. Hood	American Steel & Wire Co.
H. J. Horn	John A. Roebling's Sons Co.
L. S. Horner	Acme Wire Co.
D. J. Jackson	Dudlo Mfg. Co.
W. A. D. Peaslee	Belden Mfg. Co.
F. M. Potter	Romé Wire Co.
R. G. Thompson	North-East Electric Co.

As submitted, the specifications proposed are practically in accord with the specifications that will be proposed by the Subcommittee on Magnet Wire appointed by the Sectional Committee on Insulated Wires and Cables.

[A Division meeting will be held on Tuesday, June 19, the day of the Standards Committee meeting, at which it is anticipated that a supplementary report will be approved for submission to the Standards Committee which will cover desirable dimensions for enameled wire.]

Proposed Specifications for Magnet Wire

I. BARE COPPER

All bare copper wire used shall meet the requirements of the latest specifications of the American Society for Testing Materials for soft or annealed copper wire (Serial Designation B3-15).

II. ENAMEL

(1) *Uniformity.*—The wire shall be coated with a continuous insulating film of enamel of uniform thickness according to the dimensions shown in Table 6.

[Tables of dimensions for enamel-covered wire will be submitted by the Electrical Equipment Division at the Standards Committee meeting on June 19, 1923.]

(2) *Quality.*—The enamel coating shall be tough and elastic, and possess a hard and smooth surface. It shall be non-hygroscopic, insoluble in mineral oils, and such as to pass all tests hereinafter mentioned. All tests shall be made on wire taken directly from the spool.

(3) *Elongation Test.*—Enamel wire having a bare wire diameter of 0.0179 in. (No. 25 A.w.g.) and smaller, shall withstand elongation to the breaking-point without the enamel rupturing or flaking so that it is perceptible to the naked eye.

(4) *Mandrel Tests for Flexibility.*—At 60 to 80 deg. fahr. (15 to 27 deg. cent.) when enamel wire is wrapped as per Table 7, the enamel shall not rupture or flake so as to be perceptible to the naked eye.

(5) *Temperature Tests.*—The flexibility of the enamel shall not be impaired by baking at 212 deg. fahr. (100 deg. cent.) for 48 hr., nor lose its original gloss or luster, and the enamel shall not soften. After being allowed to cool, the enamel wire shall be capable of being wound around a mandrel as shown in Table 7, without the enamel rupturing or flaking so that it is perceptible to the naked eye.

TABLE 7—MANDREL SIZES FOR MECHANICAL TEST OF ENAMEL

Wire Size, A.w.g.	Mandrel Diameter Number of Times
8-11	5½
12-14	4
15-20	3
21-24	2

(6) *Electrical Tests.*—Dielectric tests may be conducted by either the mandrel test method or the twist test method, as outlined in the following paragraphs:

Mandrel Test.—Two layers of enameled wire shall be wound one on top of the other over a smooth mandrel of insulating material such as bakelite, hard rubber, fiber or similar material, 1 in. in diameter. The length of the winding along the mandrel shall be 1 in. and the tension applied shall not stretch or elongate the enamel wire. When alternating-current voltage at 25 to 100 cycles per second is applied between the layers the enamel shall not be punctured at less than the voltage given in Table 8. The test shall be made by applying a low voltage and raising the voltage gradually until puncture occurs. If, upon testing a sample from any spool or reel of wire, it should fail to meet this test, tests upon

TABLE 8—VOLTAGE FOR DIELECTRIC TESTS

Wire Size, A.w.g.	Voltage, A.C.
40 to 30 incl.	300
29 to 25 incl.	600
24 and larger	900

The above voltages are effective values as read on the voltmeter at breakdown.

two additional samples shall be made. If two of the three fail, the wire shall be rejected, but if two of the three withstand the test, it shall be accepted.

The transformer used in making this test shall be used under the conditions set forth in the

standardization rules of the American Institute of Electrical Engineers as to size and method of control to prevent wave distortion.

TABLE 9—TWISTS FOR DIELECTRIC TEST

Wire Size, A.w.g.	Twists per Inch
40-31	10
30-25	8
24-20	6
19-16	3
15 and larger	2

Twist Test.—Two strands of enameled wire shall be twisted together for a length of 4 in., the number of twists per inch corresponding to Table 9. The tension applied in twisting shall not be such as to stretch the wire, and the twist shall be uniform.

An alternating current of 120 volts shall be applied and gradually increased to the maximum voltages shown in Table 8 below which the enamel should not be punctured.

(7) *Effects of Oils and Waxes.*—The enamel coating shall withstand the action of transformer oil, neutral mineral-oil, lard oil and neutral waxes of a maximum temperature of 250 deg. fahr. (121 deg. cent.) for 48 hr. without injury to the enamel.

(8) *Effects of Impregnation in Varnishes.* — The enamel insulation of wire wound in coils shall not be injuriously affected by impregnation in insulation varnishes with benzine or petroleum naphtha vehicle or thinner, if properly used.

III. SINGLE COTTON
IV. DOUBLE COTTON
V. SINGLE COTTON ENAMEL
VI. DOUBLE COTTON ENAMEL

(1) *Quality.* — The covering shall consist of unbleached cotton yarn of a suitable quality obtainable for purposes of insulation.

The wrapping of yarn shall be continuous and firmly applied. Double cotton covering shall be wrapped in opposite directions.

(2) *Amount of Covering.*—Amount of covering shall be in accordance with Tables 10 and 11.

TABLE 10—MAXIMUM PERMISSIBLE ADDITIONS FOR SINGLE COTTON-COVERED WIRE

Bare Wire Diameter, In., Inclusive	Maximum Addition, In.
0.4600 to 0.1285	0.0080
0.1144	0.0070
0.1019	0.0060
0.0907 to 0.0284	0.0050
0.0253 to 0.0056	0.0045
0.0050 to 0.0031	0.0040

The minimum permissible addition to the diameter of bare wire is 85 per cent of the specified maximum.

TABLE 11—MAXIMUM PERMISSIBLE ADDITIONS FOR DOUBLE COTTON-COVERED WIRE

Bare Wire Diameter, In., Inclusive	Maximum Addition, In.
0.4600 to 0.1819	0.0160
0.1620 to 0.1285	0.0140
0.1144	0.0120
0.1019	0.0110
0.0907 to 0.0284	0.0095
0.0253 to 0.0056	0.0085
0.0050 to 0.0031	0.0080

The minimum permissible addition to the diameter of bare wire is 85 per cent of the specified maximum.

(3) *Mechanical Test for Density.*—When the wire is bent around a radius equal to five times the diameter of the wire, the cotton wrapping shall to the naked eye not open sufficiently to expose the bare wire beneath.

(4) *Insulation Tests.*—Due to the hygroscopic quality of the covering herein discussed it has not been found feasible to make a recommendation covering this test.

VII. SINGLE SILK
VIII. DOUBLE SILK
IX. SINGLE SILK ENAMEL
X. DOUBLE SILK ENAMEL

(1) *Quality.*—Covering shall consist of insulating silk yarn of a quality suitable for purposes of insulation.

The wrapping of silk yarn shall be continuous and firmly applied. Double silk covering shall be wrapped in opposite directions.

(2) *Amount of Covering.*—Amount of covering shall be in accordance with Table 12.

TABLE 12—MAXIMUM PERMISSIBLE ADDITIONS FOR SINGLE AND DOUBLE SILK-COVERED WIRE

Bare Wire Diameter, In., Inclusive	Maximum Addition, In. Single Covered	Maximum Addition, In. Double Covered
0.0570 to 0.0031	0.0020	0.0040

The minimum permissible addition to the diameter of bare wire is 75 per cent of the specified maximum.

(3) *Mechanical Test for Density.*—When the wire is bent around a radius equal to five times the diameter of the wire, the silk wrapping shall be to the naked eye not open sufficiently to expose the bare wire beneath.

(4) *Insulation Tests.*—Due to hygroscopic quality of the covering herein discussed it has not been found feasible to make a recommendation covering insulation tests.

XI. PACKING FOR ALL WIRES

(1) *Spool or Reel Dimensions.*—All wire is to be packed on standard spools as per Table 13.

TABLE 13—SPOOL DIMENSIONS

Wire Size, A.w.g.	Maximum Diameter of Head, In.	Maximum Length of Spool Overall, In.	Minimum Diameter of Arbor, In.
8-20	24	12	1¼
10-20	18	12	1¼
12-20	12	8½	1¼
14-20	9	8½	1¼
20-26	6	4¼	⅝
25-33	4½	4	⅝
25-37	4	4	⅝
34-40	3	4	⅝
38-44	2½	4	⅝

(2) *Continuity of Winding.*—The wire shall be in one continuous length in each package. Such joints as may be necessary to bring the wire up to the minimum weight called for in Table 13 shall be made by brazing in a good workmanlike manner so that the diameter of the wire after brazing is substantially the same as in the other portion of the wire, and the joint must be so smoothed-down that there will be no rough places to cut the insulation. The wire at a joint must be substantially identical in softness and dimensions with the rest of the wire and have at least 95 per cent of its strength.

(3) *Density of Winding.*—The wire shall be wound on spools under such a tension as will give an even and compact winding. A soft body of wire on the spool will not be satisfactory. On 0.0201 in. (No. 24 A.w.g.) and finer the inner end of the wire on a spool must be brought out so that it will be available.

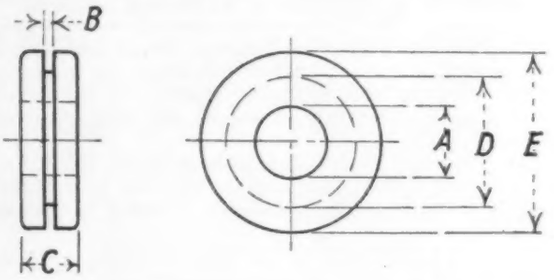
Rubber Bushings

(Proposed S. A. E. Standard)

The Electrical Equipment Division recommends the adoption of the accompanying dimensions for soft rubber bushings or grommets for use in installing automotive electric wiring, tubing and speedometer drives, where they pass through sheet metal, to prevent chafing. The proposed standard was formulated by the Subdivision on Automobile Wiring, the personnel of which is given below.

W. S. Haggott, *Chairman*	Packard Electric Co.
H. B. Burley	Boston Insulated Wire & Cable Co.
M. L. Hillmer	Remy Electric Co.
B. M. Leece	Leece-Neville Co.
B. M. Smarr	General Motors Corporation
C. H. Williams	Studebaker Corporation of America
Ernest Wooler	Cleveland Automobile Co.

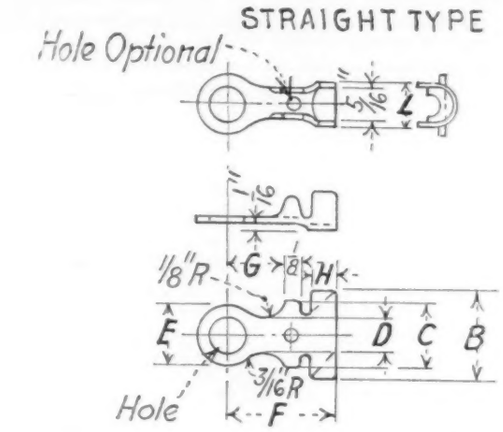
In addition to the subjects of Automobile Wiring and Rubber Bushings, the Subdivision was also assigned the subjects of Cable Terminals and Clips, reports covering these being given hereinafter. The work on automobile wiring, which covers the standardization of a color code for the cable braid of the principal circuits, is still in progress.



A	*B*	*C*	*D*	*E*
17/64	1/16	5/16	15/32	5/8
17/64	3/16	7/16	15/32	5/8
21/64	1/16	5/16	17/32	23/32
21/64	3/16	7/16	17/32	23/32
25/64	1/16	5/16	21/32	27/32
25/64	3/16	7/16	21/32	27/32
33/64	1/16	5/16	27/32	1 1/16
33/64	3/16	7/16	27/32	1 1/16
41/64	1/16	5/16	31/32	1 3/16
41/64	3/16	7/16	31/32	1 3/16
49/64	1/16	5/16	1 3/32	1 5/8
49/64	3/16	7/16	1 3/32	1 5/8
1 1/32	1/16	5/16	1 11/32	1 9/16
1 1/32	3/16	7/16	1 11/32	1 9/16

Material.—Rubber sufficiently soft to permit the bushing or grommet to be inserted in a hole of the size recommended without being cut.

Note.—The recommended size for the hole in the metal in which a bushing or grommet is inserted shall be 1/32-in. larger than dimension *D*.



Recommended		Terminal Dimensions									
Size of Cable	Size of Screw	Diameter of Hole	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*L*	Thickness
Nos. 16, 14, 12	No. 8 or 10	0.201	21/32	1/2	5/16	3/8	13/16	7/32	7/32	7/32	0.030
Nos. 12, 10	No. 8 or 10	0.201	23/32	5/8	7/16	3/8	13/16	3/8	7/32	7/32	0.030
Nos. 12, 10	1/4	5/32	23/32	5/8	7/16	1/2	13/16	3/8	7/32	7/32	0.040
Nos. 12, 10	5/16	11/32	23/32	5/8	7/16	1/2	13/16	3/8	7/32	7/32	0.040
Nos. 12, 10	3/8	11/32	23/32	5/8	7/16	13/16	7/8	7/16	7/32	7/32	0.040

Alternate Construction.—The wings which clamp the cable may be cut diagonally as indicated by dotted lines.

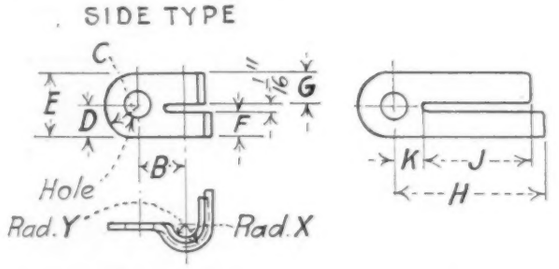
Material.—Soft sheet copper, S. A. E. Specification No. 71, or Soft Sheet Brass, S. A. E. Specification No. 70.

Note.—Terminals must be free from burrs, corrosion or any foreign matter. The temper of terminals must be sufficiently soft to permit of the terminals being assembled with wings closed and not show any fracture or cracks which will impair the strength of the assembly.

Cable Terminals

(Proposed Revision of S. A. E. Standard)

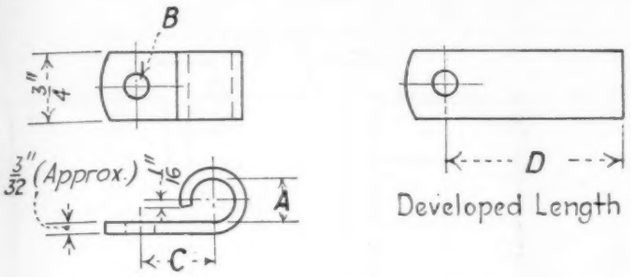
The Electrical Equipment Division submits four types of cable terminal for adoption in place of the present cable terminal standards, pp. B21 and B22 of the S.A.E.



Recommended		Terminal Dimensions											
Size of Cable	Size of Screw	Diameter of Hole	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*J*	*K*	*Y*	*X*	Thickness
Nos. 16, 14, 12	No. 8 or 10	0.201	3/8	1/4	1/4	1/2	7/16	1/4	13/16	7/16	1/4	3/64	3/64	0.040
Nos. 12, 10	No. 8 or 10	0.201	1/2	1/4	1/4	1/2	9/16	1/4	13/16	13/32	1/4	3/64	3/64	0.040
Nos. 12, 10	1/4	5/32	1/2	1/4	1/2	1/2	9/16	1/4	13/16	13/32	5/32	3/64	3/64	0.040
Nos. 12, 10	5/16	11/32	1/2	5/16	1/4	1/2	9/16	5/16	13/16	13/32	5/32	3/64	3/64	0.040
Nos. 12, 10	3/8	11/32	1/2	5/16	1/4	1/2	9/16	5/16	7/8	13/32	5/32	3/64	3/64	0.040

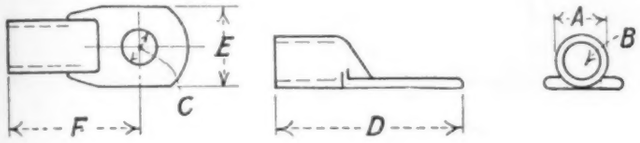
Material.—Soft Sheet Copper, S. A. E. Specification No. 71, or Soft Sheet Brass, S. A. E. Specification No. 70.

Note.—Terminals must be free from burrs, corrosion or any foreign matter. The temper of terminals must be sufficiently soft to permit of the terminals being assembled with wings closed and not show any fracture or cracks which will impair the strength of the assembly.



Size	Wire Size, A.w.g.	A	B	C	D
4	4	5/16	9/32	11/16	1 23/32
4	4	5/16	11/32	11/16	1 23/32
1	2	13/32	11/32	3/4	2
1	1	13/32	13/32	3/4	2
0	0	1/2	11/32	13/16	2 9/32
0	00	1/2	13/32	13/16	2 9/32

Material.—Soft Sheet Copper, S. A. E. Specification No. 71.



Size A	Wire Size, A.w.g.	B	C	D	E	F
3/8	4	0.285	9/32	1 11/32	17/32	1 1/16
3/8	4	0.285	11/32	1 11/32	17/32	1 1/16
7/16	2	0.336	11/32	1 1/2	5/8	1 5/32
7/16	2	0.336	13/32	1 1/2	5/8	1 5/32
1/2	1	0.398	11/32	1 3/4	3/4	1 11/32
1/2	1	0.398	13/32	1 3/4	3/4	1 11/32
9/16	0	0.461	13/32	2	13/16	1 9/16
5/8	00	0.511	13/32	2 1/8	29/32	1 5/8

Material.—Soft Sheet Copper, S. A. E. Specification No. 71.

HANDBOOK. For generators, switches and meters, the straight and side types of terminals are proposed as given in the accompanying Tables.

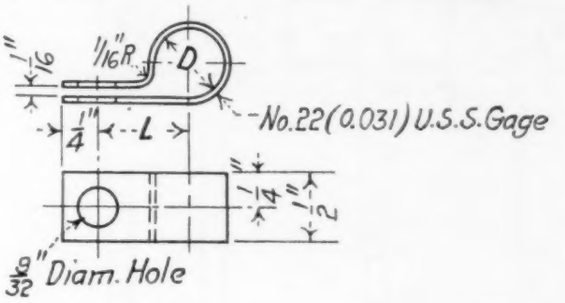
For starting-motor cable terminals, two types are proposed: the rolled type, which represents an extension of the existing standard, and the straight type. The dimensions proposed are given in the accompanying Tables.

The report was prepared by the Subdivision on Automobile Wiring when it was found that the existing cable terminal standards were not used as extensively as it was hoped they would be when the standards were originally approved. It is felt that the revised standards will be used by practically all manufacturers as they follow closely the standards already established by the terminal manufacturers for the greater part of their production.

CLIPS

(Proposed S.A.E. Standard)

The Electrical Equipment Division recommends the adoption as S.A.E. Standard of the accompanying table of clip dimensions. The diameters selected permit the



D	L	D	L	D	L
3/16	15/32	1/2	5/8	1	7/8
1/4	1/2	9/16	21/32	1 1/8	15/16
5/16	17/32	5/8	11/16	1 7/16	1 1/32
3/8	9/16	3/4	3/4		
7/16	19/32	7/8	13/16		

Material.—Sheet or Strip Steel, S. A. E. Steel No. 1010.

use of the proposed clips for cable, conduit and flexible tubing. They may also be used for gasoline tubing.

STARTING-MOTOR MOUNTINGS

(Proposed Extension of S.A.E. Recommended Practice)

The present S.A.E. Recommended Practice for the barrel type of starting-motor mounting, p. B16b of the S.A.E. HANDBOOK, specifies limits of 3.496 to 3.499 in. for the diameter of the barrel. The diameter of the bore in the flywheel housing in which the barrel is mounted is not specified.

After obtaining the recommendations of the Engine Division members as to what the limits for the bore should be, the Electrical Equipment Division recommends that the present standard be revised by the addition of the following note.

> The limits of the bore in the flywheel housing in which the barrel type of starting motor is mounted, shall be 3.500 to 3.503 in.

These limits permit a fit of from 0.001 to 0.007 in., which is considered satisfactory as in production the diameter of the starting-motor barrel runs to the high limit.

ELECTRIC VEHICLE DIVISION REPORT

Division Personnel

E. L. Clark, *Chairman*	Commercial Truck Co.
Karl Probst, *Vice-Chairman*	Milburn Wagon Co.
G. L. Bixby	Detroit Electric Car Co.
A. K. Brumbaugh	Autocar Co.
J. G. Carroll	Walker Vehicle Co.
H. M. Pierce	Ward Motor Vehicle Co.
F. E. Queeney	Lansden Co., Inc.
C. R. Skinner, Jr.	New York Edison Co.

BATTERY TRAYS FOR ELECTRIC TRUCKS

(Proposed S.A.E. Recommended Practice)

About a year and a half ago the need for standardizing the sizes and the arrangement of storage-battery trays for electric trucks was brought to the division's atten-

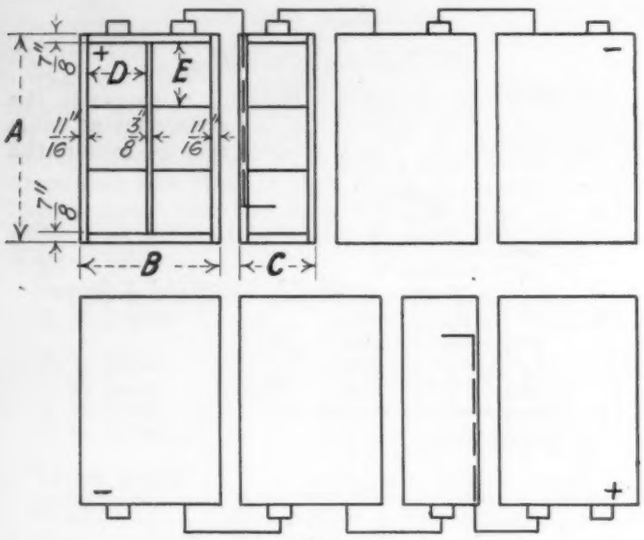


FIG. 1

Nominal Truck Capacity, Tons	Range of Jar Widths, In. Inclusive	*A* Max.	*B* Max.	*C* Max.	*D*	*E*	Fig. No.
½	Up to $4\frac{5}{16}$	$20\frac{1}{2}$	$10\frac{1}{2}$	$5\frac{3}{4}$	$4\frac{5}{16}$	$6\frac{3}{16}$	1
1	$4\frac{5}{16}$ to $5\frac{1}{16}$	$20\frac{1}{2}$	12	$6\frac{1}{2}$	$5\frac{1}{16}$	$6\frac{3}{16}$	1
2	$5\frac{9}{16}$ to $6\frac{7}{8}$	$22\frac{9}{16}$	$14\frac{3}{8}$	$7\frac{11}{16}$	$6\frac{1}{4}$	$6\frac{7}{8}$	1
$3\frac{1}{2}$	$7\frac{1}{8}$ to $8\frac{1}{8}$	$27\frac{11}{16}$	$9\frac{5}{8}$	...	$8\frac{1}{8}$	$6\frac{1}{4}$	2
5	$8\frac{5}{8}$ to $10\frac{5}{8}$	$27\frac{11}{16}$	$12\frac{1}{8}$	...	$10\frac{5}{8}$	$6\frac{1}{4}$	2

Maximum height of all lead-acid tray assemblies shall be 16 in.

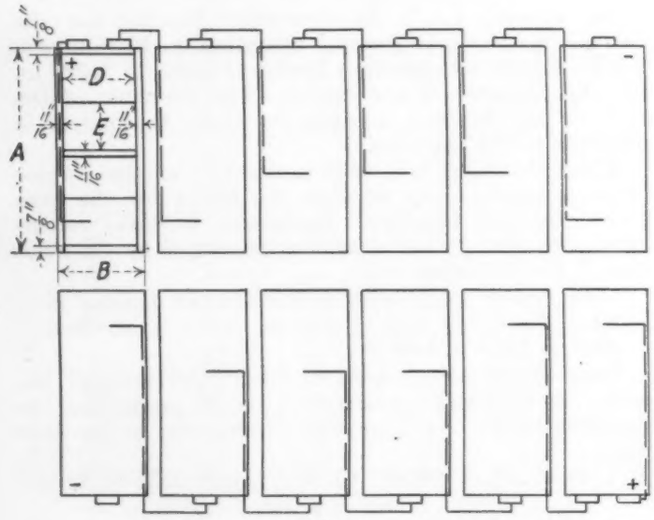


FIG. 2

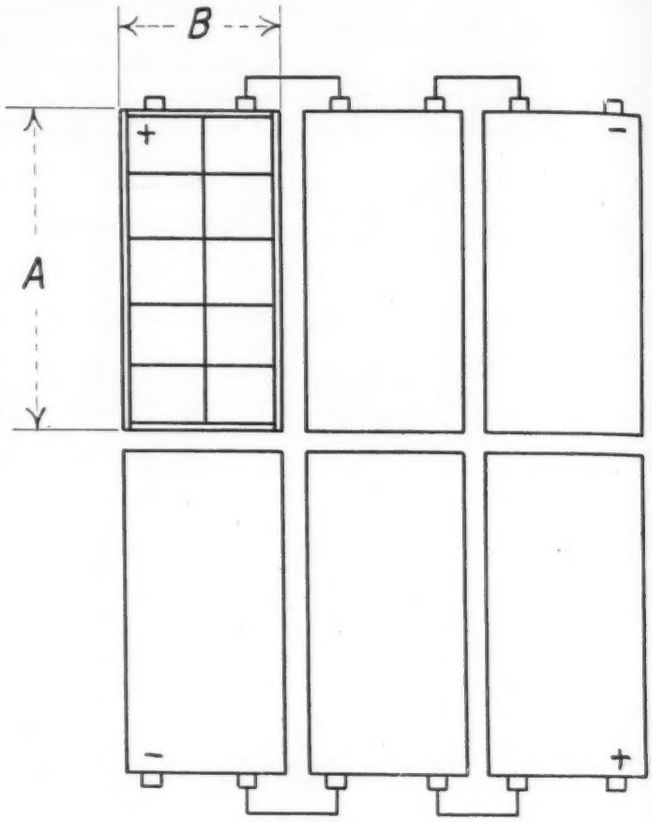


FIG. 3

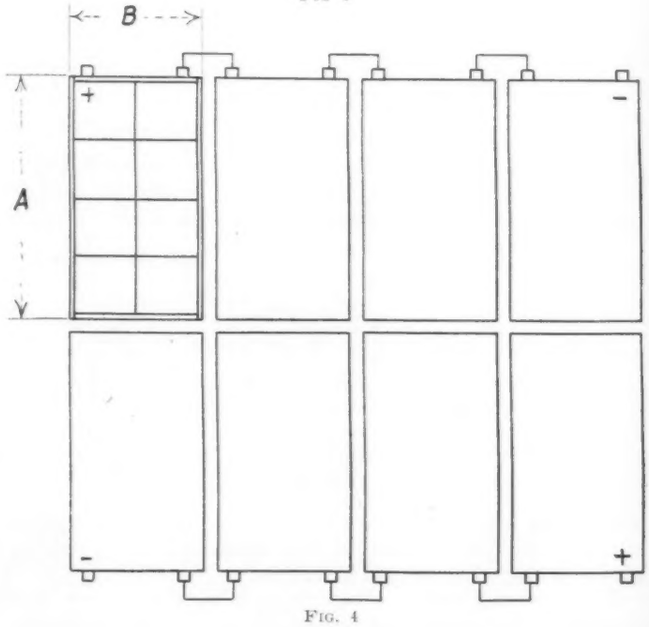


FIG. 4

tion. As electric trucks are usually operated in fleets, it is important that adequate provision be made for removing the batteries for recharging and replacing them with fully charged batteries. Operators of fleets of more than one make of truck have been particularly troubled in this connection and have evidenced a strong desire for a remedy. A Subdivision comprising E. L. Clark and Bruce Ford was appointed to study the situation and prepare a recommendation in 1922. Data were gathered and several meetings held at which tentative reports were thoroughly considered.

The Division now presents the following report for adoption as S.A.E. Recommended Practice in the belief that the dimensions recommended, if adhered to by the battery and electric-truck manufacturers in the future, will eliminate the trouble that has been experienced in charging the batteries and will materially reduce the number of battery sizes the battery manufacturers will have to make. The various types of cradle now used have been carefully considered and it is believed that the recommendation can be followed by all manufacturers with no serious changes in cradle design.

TABLE 5—NICKEL-IRON STORAGE-BATTERY TRAYS

Nominal Truck Capacity, Tons	Type of Battery	A[1]	B	Battery Height[2]	Fig. No.
½	A- 5	20½	12¼	15⅛	3
1	A- 6	23 7/32	12¼	15⅛	3
	A- 7	26⅛	12¼	15⅛	3
2	A- 8	24⅝	12¼	15½	4
3½	A-10	26⅜	15½	15½	4
5	A-12	26⅜	18	16¼	4

[1] Including ¼-in. bumpers at both ends. In adding terminal plate subtract ¼ in. from terminal plate height.
[2] Maximum height of batteries in trays, with caps closed.

CHARGING-PLUGS AND RECEPTACLES

(Proposed Revision of S. A. E. Standard)

As it has been ascertained that the S.A.E. Standard 150-amp. charging-plug and receptacle is used only on electric street-trucks, the 50-amp. charging-plug and receptacle being used on passenger vehicles and industrial trucks, the Electric Vehicle Division recommends that this distinction be specified in the present S.A.E. Standard for Charging-Plugs and Receptacles, p. B38 of the S.A.E. HANDBOOK.

ELECTRIC VEHICLE MOTORS

(Proposed Revision of S.A.E. Recommended Practice)

The Electric Vehicle Division recommends that the present S.A.E. Recommended Practice for Electric Vehicle Motors, p. B41 of the S.A.E. HANDBOOK, be revised so that the recommendations for motor ratings shall read

> The rating of electric automobile propulsion motors shall be based on a temperature-rise not to exceed 65 deg. cent. (117 deg. fahr.) by thermometer, or 75 deg. cent. (135 deg. fahr.) by resistance after 4 hr. of continuous operation at normal rated load.
>
> The tests shall be made on a stand with the motor-covers arranged as in service.

The revised rating omits specifying at what room-temperature the test shall be made because it is impracticable to conduct tests with a constant room-temperature.

ENGINE DIVISION REPORT

Division Personnel

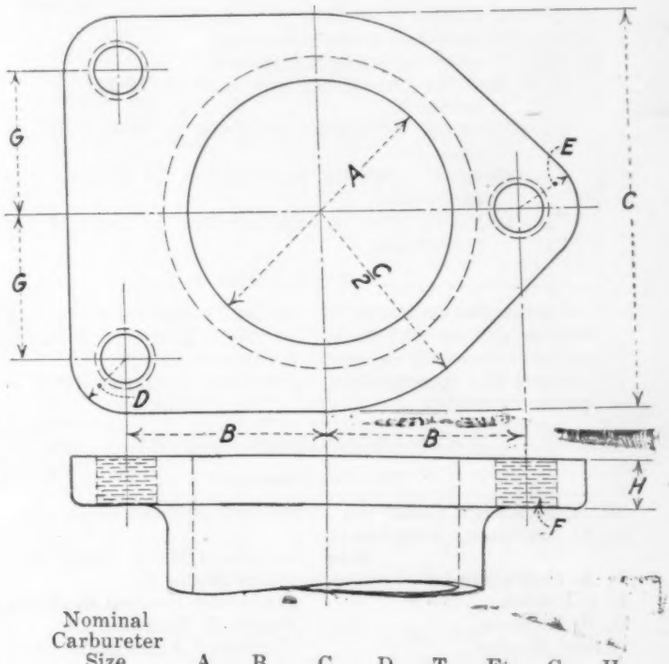
J. B. Fisher, *Chairman*	Waukesha Motor Co.
R. J. Broege, *Vice-Chairman*	Buda Co.
P. J. Dasey	Midwest Engine Co.
S. F. Evelyn	Continental Motors Corporation
P. E. Holt	Holt Mfg. Co.
A. F. Milbrath	Wisconsin Motor Mfg. Co.
Louis Schwitzer	Automotive Parts Co.
M. J. Steele	Packard Motor Car Co.
Joseph VanBlerck	Joseph VanBlerck Engine Corporation
W. C. Ware	Fay & Bowen Engine Co.

CARBURETER FLANGES

(Proposed Extension of S. A. E. Recommended Practice)

The Engine Division recommends that the present S.A.E. Recommended Practice for Carbureter Flanges, p. A8 of the S.A.E. HANDBOOK, be extended to include the accompanying three-bolt type carbureter flange for motorcycle engines. The dimensions proposed are used extensively at the present time, having been developed to meet the special requirements necessitated by the lack of space and the excessive vibration in motorcycles.

The Division also recommends, in view of the fact that since the original specification for carbureter flanges was adopted by the Society in 1912 and has come into almost universal use, that the status be changed from S.A.E. Recommended Practice to S.A.E. Standard.



Nominal Carbureter Size	A	B	C	D	T	F	G	H
¾	15/16	23/32	1¾	¼	¼	¼-24	⅝	¼
1	1⅛	23/32	1¾	¼	5/16	¼-24	⅝	¼
1¼	1⅜	1 1/32	2 1/16	9/32	5/16	5/16-18	¾	¼

[3] S. A. E. Form of Thread.

ENGINE TESTING FORMS

(Proposed Revision of S. A. E. Standard)

At the meeting of the Standards Committee in January, 1922, the recommendation of the Engine Division as to various revisions of the present S.A.E. Standard Engine Testing Forms was referred back for further consideration, particularly in reference to the temperature specified for recording the cold test and the Saybolt viscosity.

The original report specified temperatures of 150 and 350 deg. fahr. Action on this subject was deferred by the Engine Division until the report of the Lubricants Division on crankcase lubricating oils was approved by the Society. As the report, which is now printed on p. D151 of the S.A.E. HANDBOOK, specifies temperatures of 100 and 210 deg. fahr., the Engine Division recommends that the original recommendation of the Division be resubmitted for approval with the exception that the temperatures specified for recording the cold test and the Saybolt viscosity shall be 100 and 210 deg. fahr. The definite revisions proposed by the Engine Division follow:

SPECIFICATION SHEET B

Under Item No. 6, Cooling System, provide for recording the fan diameter, projected width of fan-blades and the ratio of fan speed to engine speed.

Under Item No. 32, Lubricating System, Type and

Description, provide for recording the cold test and the Saybolt viscosity at 100 and 210 deg. fahr.

Add a section entitled, Accessories, containing Item 33, Accessories Attached during Test, under which are to be listed the accessories attached to the engine during the test and conditions under which they operated.

LOG SHEET C

Add a note to the effect that it is recommended that results be corrected to a temperature of 60 deg. fahr. and 29.92 in. of mercury barometric pressure by using the formula.

$B.Hp._c = B.Hp._o \times (P_s/P_o) \times \sqrt{(T_o/T_s)}$

$B.Hp._c$ = corrected brake-horsepower

$B.Hp._o$ = observed brake-horsepower

P_o = observed barometric pressure in inches of mercury

P_s = standard barometric pressure in inches of mercury

T_o = observed absolute temperature in degrees fahrenheit

T_s = standard absolute temperature in degrees fahrenheit

CURVE SHEET D

Change the ordinates for the fuel consumption from "0.5 to 2.5" to "0.5 to 1.5" lb. per b.hp-hr. so that 4 ordinate lines will represent 0.1 lb. per b.hp-hr.

Insert the intermediate values for the brake-horsepower ordinates.

FRAMES DIVISION REPORT

Division Personnel

W. A. McKinley, *Chairman*	Detroit Pressed Steel Co.
C. C. Bowman, *Vice-Chairman*	Standard Motor Truck Co.
E. A. DeWaters	Buick Motor Co.
L. J. Fralick	Hydraulic Pressed Steel Co.
O. B. Harmon	Parish & Bingham Co.
Ernest Wooler	Cleveland Automobile Co.

PASSENGER-CAR FRAMES

(*Proposed Cancellation of S. A. E. Recommended Practice*)

The Frames Division recommends that the present S.A.E. Recommended Practice for Passenger-Car Frames, p. H21 of the S.A.E. HANDBOOK, be cancelled. The recommended practice was adopted in 1915, at which time it was logical and satisfactory for existing conditions, but subsequent development has rendered it obsolete. It is felt that no standards should be set-up at this time for passenger-car frames as their design depends largely upon individual chassis and body design.

IRON AND STEEL DIVISION REPORT

Division Personnel

F. P. Gilligan, *Chairman*	Henry Souther Engineering Corporation
W. C. Peterson, *Vice-Chairman*	Atlas Steel Corporation
R. J. Allen	Rolls-Royce of America, Inc.
R. M. Bird	Bethlehem Steel Co.
H. T. Chandler	Metallurgist
A. L. Colby	Consulting Metallurgist
B. F. Courtright	Wisconsin Steel Co.
L. A. Danse	Cadillac Motor Car Co.
C. N. Dawe	Studebaker Corporation of America
B. H. DeLong	Carpenter Steel Co.
E. W. Ehn	Timken Roller Bearing Co.
A. P. Eves	International Harvester Co.
H. L. Greene	Willys-Overland Co.
G. F. Harper	Allis-Chalmers Mfg. Co.
W. H. Higgins, Jr.	Advance Rumely Co., Inc.
E. J. Janitzky	Illinois Steel Co.
J. B. Johnson	Air Service
F. C. Langenberg	Watertown Arsenal
F. E. McCleary	Dodge Bros.
C. S. Moody	Minneapolis Steel & Machinery Co.
J. H. Nelson	Wyman-Gordon Co.
G. L. Norris	Vanadium Corporation of America
W. H. Phillips	R. D. Nuttall Co.
S. P. Rockwell	Metallurgical Engineer
M. P. Rumney	Detroit Steel Products Co.
C. F. W. Rys	Carnegie Steel Co.
R. B. Schenck	Buick Motor Co.
M. H. Schmid	United Alloy Steel Corporation
H. J. Stagg	Halcomb Steel Co.
J. M. Watson	Hupp Motor Car Corporation
H. M. Williams	General Motors Research Corporation
J. H. G. Williams	Billings & Spencer

IRON AND STEEL SPECIFICATIONS

PART X—EFFECT OF MASS UPON THE PHYSICAL PROPERTIES OF STEEL

(*Proposed General Information*)

The charts of physical properties for S.A.E. Steels, appearing in the S.A.E. HANDBOOK, apply to sections up to 1½-in. diameter or thickness. As the size or the mass of the steel object being heat-treated is increased, the response of the steel to the quenching operation is less marked. Owing to the lack of comprehensive detailed data as to the exact influence of mass upon the physical properties of S.A.E. Steels, the Iron and Steel Division has collected such data as have been available, and a large number of confirmatory tests have been made by representative steel manufacturers and a few steel consumers. The data thus obtained have been prepared in chart form for the information of the members of the Society. Owing to the large amount of work involved in making confirmatory tests, only one steel of each type has been selected, and each of these steels subjected to the following forms of heat-treatments:

(1) Water-quenched and tempered at 1000 deg. fahr.
(2) Oil-quenched and tempered at 1000 deg. fahr.
(3) Water-quenched and tempered at 1200 deg. fahr.
(4) Oil-quenched and tempered at 1200 deg. fahr.

The Iron and Steel Division desires to emphasize that the charts submitted herewith are for purposes of information only and should not be considered as providing absolute values.

It is hoped by the Division that users of large sections will collect and forward to the Division any test data they may have on any S.A.E. Steels in order that these charts may be further verified and extended.

PART IX—GENERAL HEAT-TREATMENTS

SPRING STEEL WIRE

(*Proposed Extension of General Information*)

The Iron and Steel Division recommends that the general information in reference to S.A.E. Steels 1350 and 1360, p. D29a of the S.A.E. HANDBOOK, be extended to include the following sentence:

> For conditions where carbon steels are not suitable, certain alloy steels are available.

It is felt desirable that this sentence be included as a reminder, to users of the specifications, of data already covered elsewhere in the general information in reference to the applications of the various steels.

Chart for S.A.E. Steel 1045

Chemical Composition in Percentage

Carbon	0.40 —0.50
Manganese	0.50 —0.80
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1500 deg. fahr. in oil.
Drawn at 1000 deg. fahr.

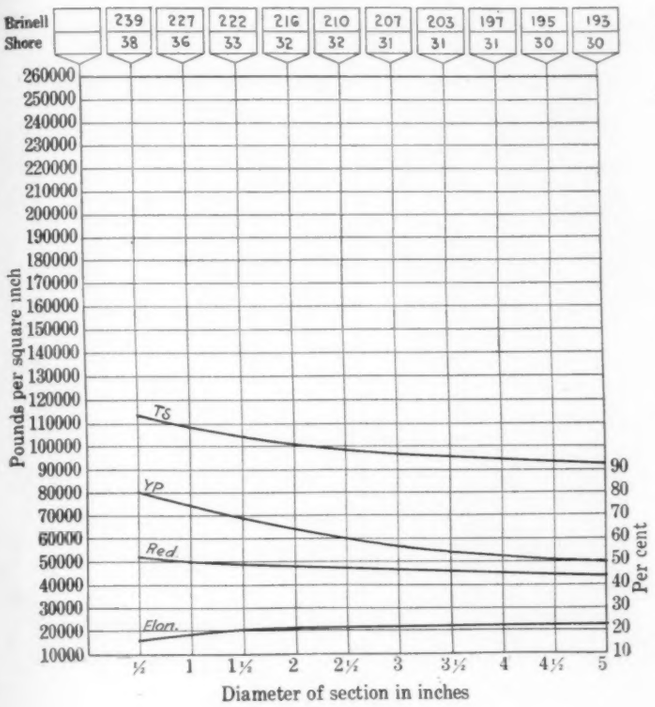


Chart for S.A.E. Steel 1045

Chemical Composition in Percentage

Carbon	0.40 —0.50
Manganese	0.50 —0.80
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1500 deg. fahr. in oil.
Drawn at 1200 deg. fahr.

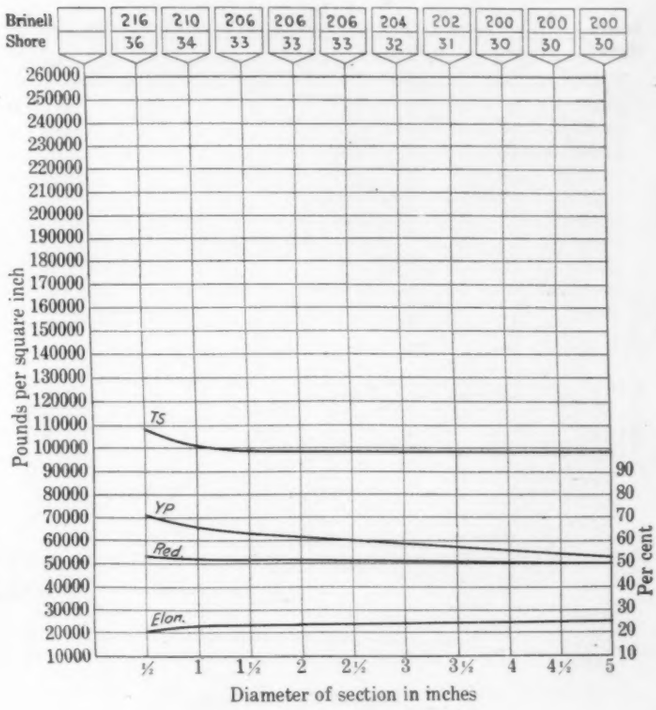


Chart for S.A.E. Steel 1045

Chemical Composition in Percentage

Carbon	0.40 —0.50
Manganese	0.50 —0.80
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1500 deg. fahr. in water.
Drawn at 1000 deg. fahr.

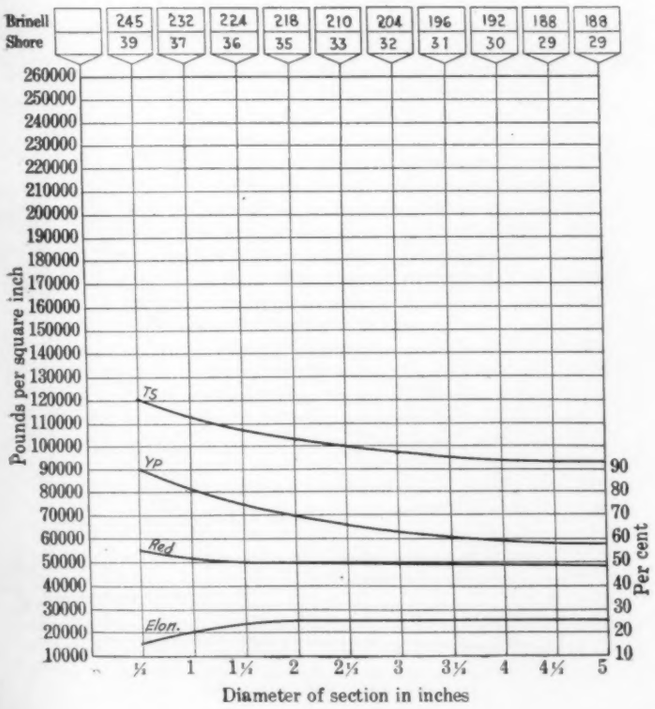


Chart for S.A.E. Steel 1045

Chemical Composition in Percentage

Carbon	0.40 —0.50
Manganese	0.50 —0.80
Phosphorus	0.045 max.
Sulphur	0.05 max.

Quenched at 1500 deg. in water.
Drawn at 1200 deg. fahr.

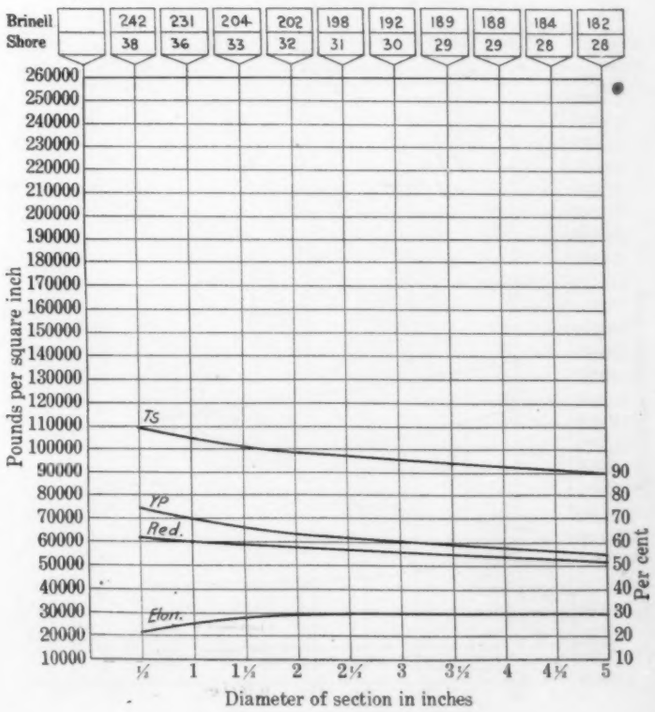


Chart for S.A.E. Steel 2340

Chemical Composition in Percentage

Carbon	0.35 —0.45
Manganese	0.50 —0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25 —3.75

Normalized at 1625 to 1675 deg. fahr.
Quenched at 1450 deg. fahr. in oil.
Drawn at 1000 deg. fahr.

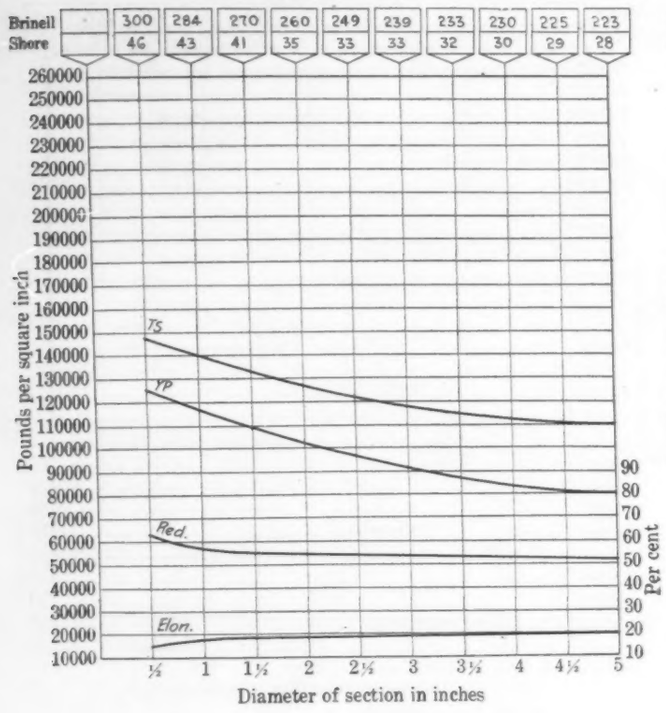


Chart for S.A.E. Steel 2340

Chemical Composition in Percentage

Carbon	0.35 —0.45
Manganese	0.50 —0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25 —3.75

Normalized at 1625 to 1675 deg. fahr.
Quenched at 1450 deg. fahr. in oil.
Drawn at 1200 deg. fahr.

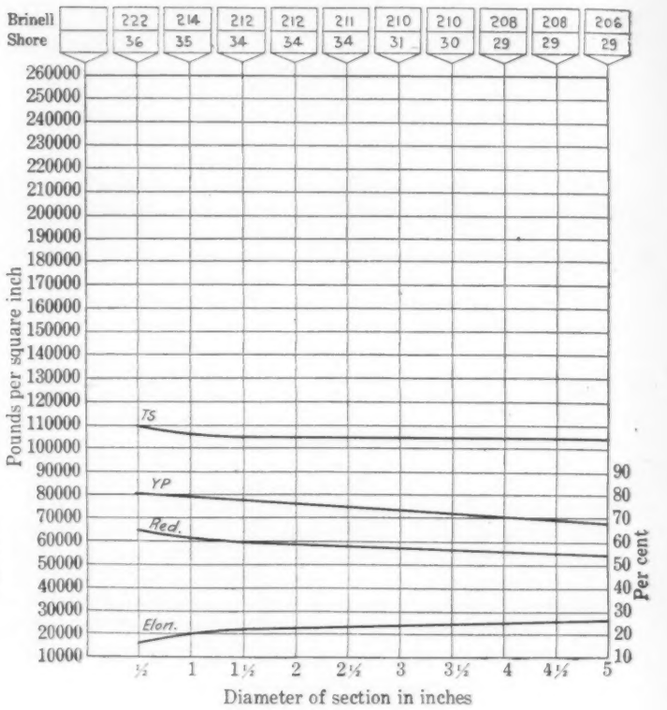


Chart for S.A.E. Steel 2340

Chemical Composition in Percentage

Carbon	0.35 —0.45
Manganese	0.50 —0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25 —3.75

Normalized at 1625 to 1675 deg. fahr.
Quenched at 1450 deg. fahr. in water.
Drawn at 1000 deg. fahr.

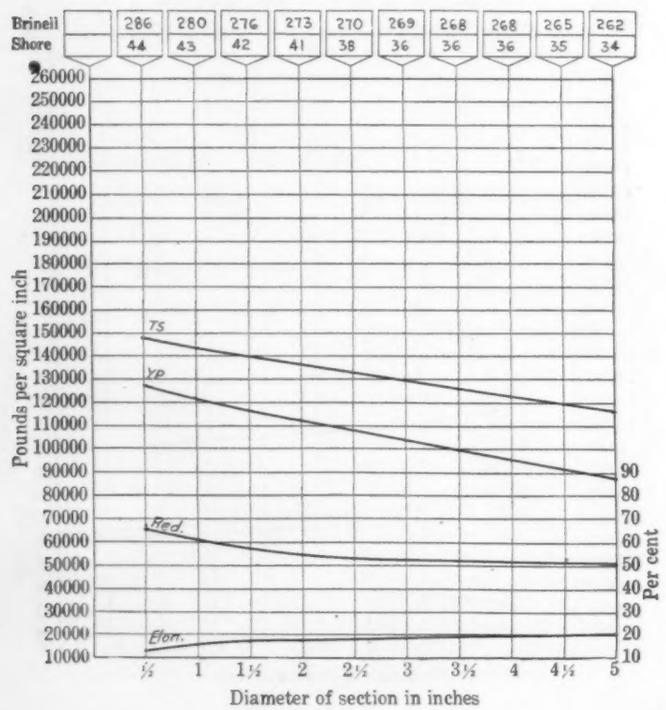


Chart for S.A.E. Steel 2340

Chemical Composition in Percentage

Carbon	0.35 —0.45
Manganese	0.50 —0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	3.25 —3.75

Normalized at 1625 to 1675 deg. fahr.
Quenched at 1450 deg. fahr. in water.
Drawn at 1200 deg. fahr.

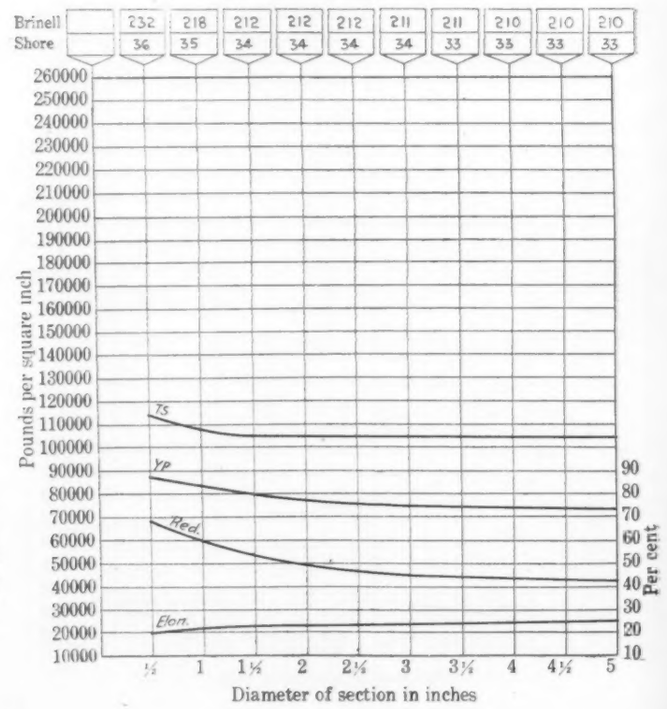


Chart for S.A.E. Steel 3140

Chemical Composition in Percentage

Carbon	0.35 —0.45
Manganese	0.50 —0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	1.00 —1.50
Chromium	0.45 —0.75

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1500 deg. fahr. in oil.
Drawn at 1000 deg. fahr.

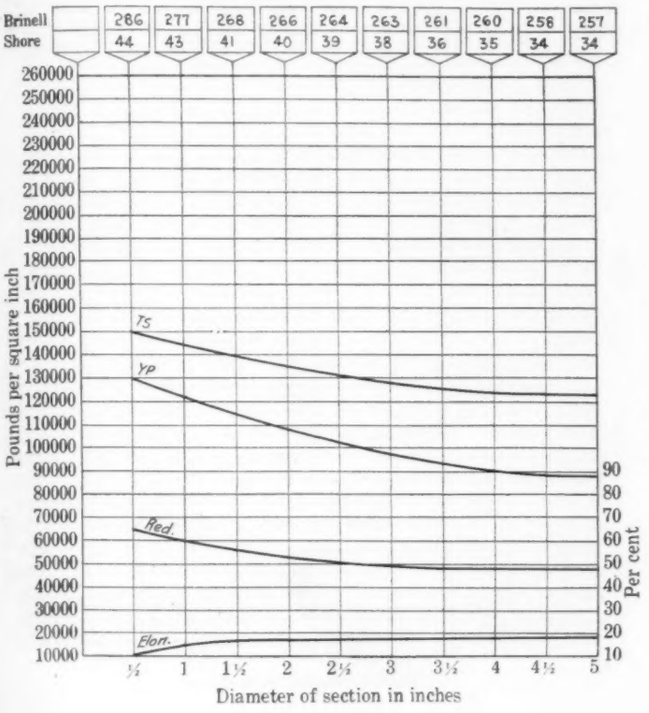


Chart for S.A.E. Steel 3140

Chemical Composition in Percentage

Carbon	0.35 —0.45
Manganese	0.50 —0.80
Phosphorus	0.04 max.
Sulphur	0.045 max.
Nickel	1.00 —1.50
Chromium	0.45 —0.75

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1500 deg. fahr. in oil.
Drawn at 1200 deg. fahr.

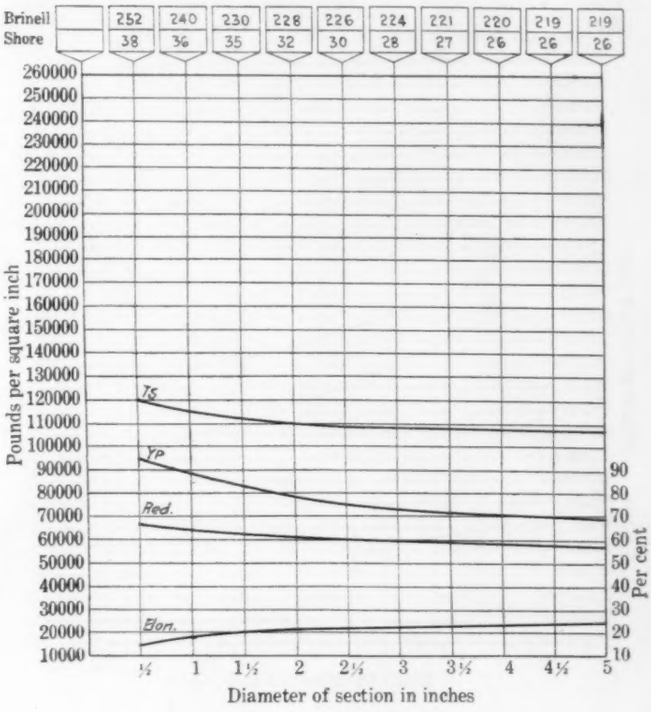


Chart for S.A.E. Steel 3140

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1500 deg. fahr. in water.
Drawn at 1000 deg. fahr.

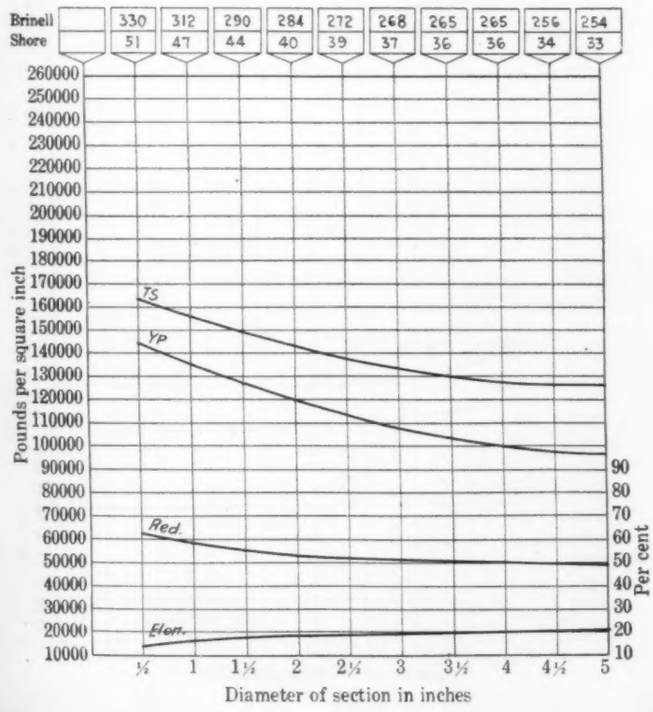


Chart for S.A.E. Steel 3140

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1500 deg. fahr. in water.
Drawn at 1200 deg. fahr.

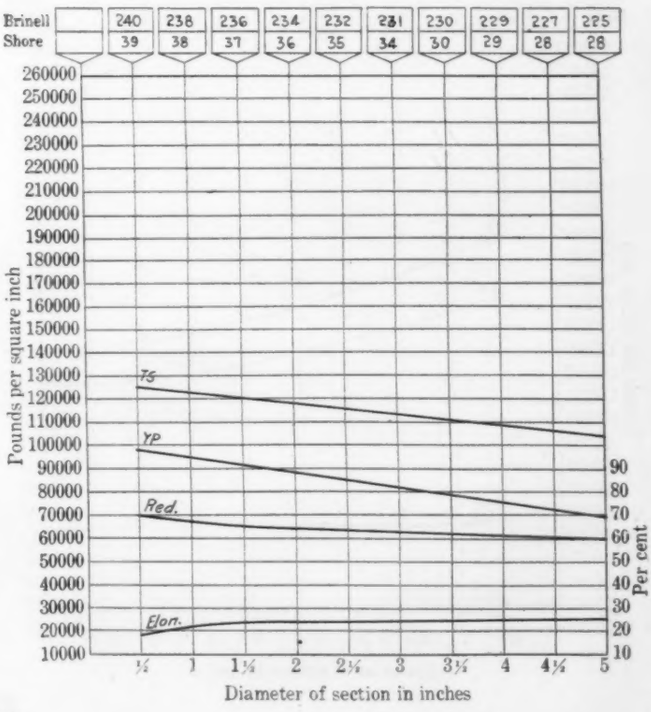


Chart for S.A.E. Steel 3240

Chemical Composition in Percentage

Carbon	0.35—0.45
Manganese	0.30—0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50—2.00
Chromium	0.90—1.25

Normalized at 1625 to 1675 deg. fahr.
Quenched at 1500 deg. fahr. in oil.
Drawn at 1000 deg. fahr.

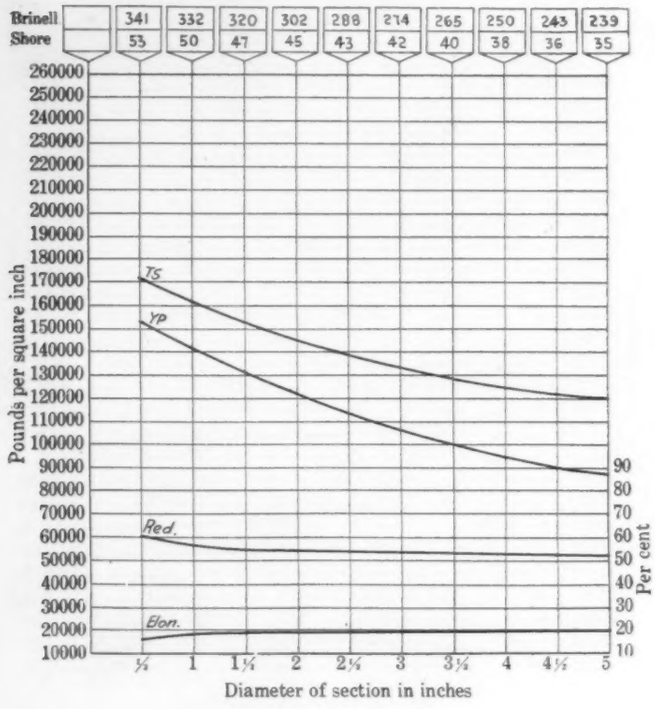


Chart for S.A.E. Steel 3240

Chemical Composition in Percentage

Carbon	0.35—0.45
Manganese	0.30—0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	1.50—2.00
Chromium	0.90—1.25

Normalized at 1625 to 1675 deg. fahr.
Quenched at 1500 deg. fahr. in oil.
Drawn at 1200 deg. fahr.

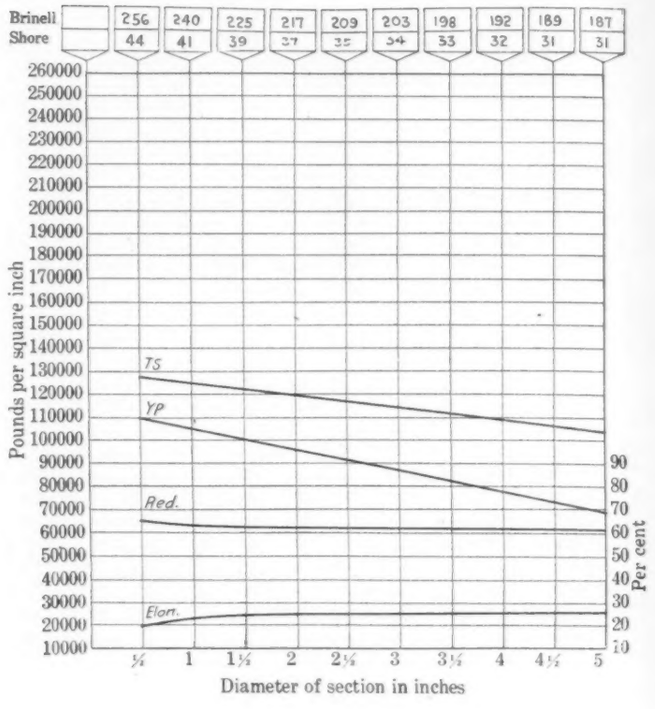


Chart for S.A.E. Steel 3240

Normalized at 1625 to 1675 deg. fahr.
Quenched at 1500 deg. fahr. in water.
Drawn at 1000 deg. fahr.

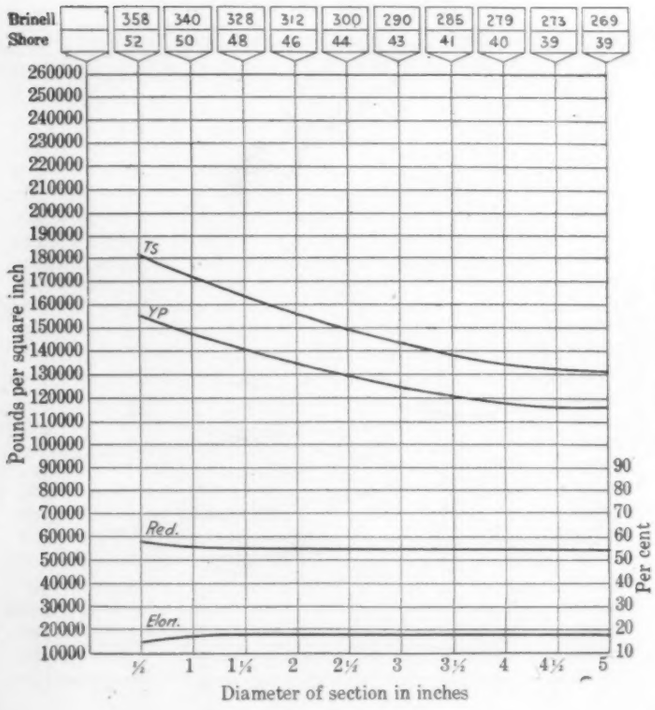


Chart for S.A.E. Steel 3240

Normalized at 1625 to 1675 deg. fahr.
Quenched at 1500 deg. fahr. in water.
Drawn at 1200 deg. fahr.

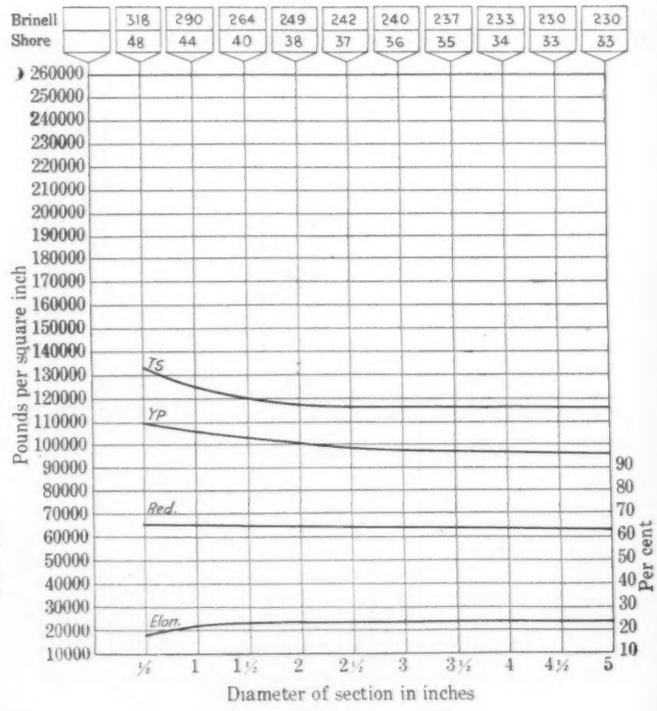


Chart for S.A.E. Steel 3340

Chemical Composition in Percentage

Carbon	0.35—0.45
Manganese	0.30—0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	3.25—3.75
Chromium	1.25—1.75

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1450 deg. fahr. in oil.
Drawn at 1000 deg. fahr.

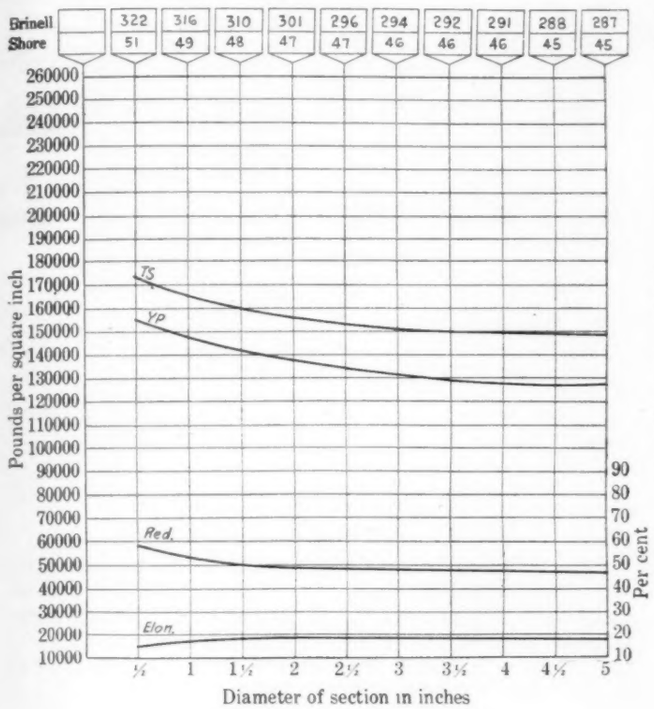


Chart for S.A.E. Steel 3340

Chemical Composition in Percentage

Carbon	0.35—0.45
Manganese	0.30—0.60
Phosphorus	0.04 max.
Sulphur	0.04 max.
Nickel	3.25—3.75
Chromium	1.25—1.75

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1450 deg. fahr. in oil.
Drawn at 1200 deg. fahr.

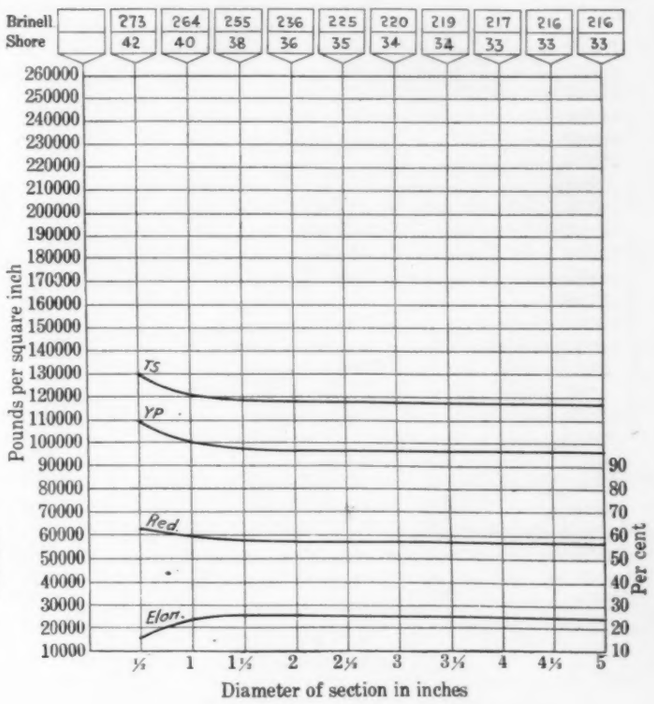


Chart for S.A.E. Steel 3340

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1450 deg. fahr. in water.
Drawn at 1000 deg. fahr.

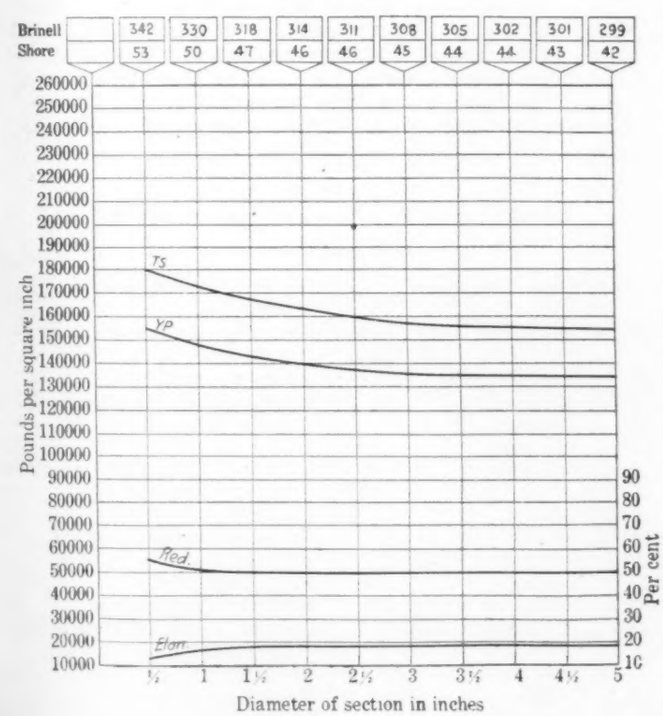


Chart for S.A.E. Steel 3340

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1450 deg. fahr. in water.
Drawn at 1200 deg. fahr.

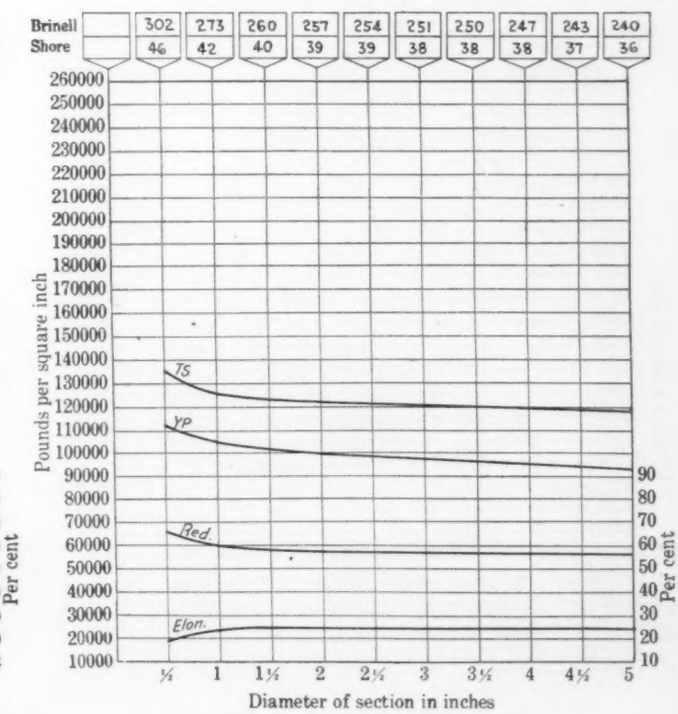


CHART FOR S.A.E. STEEL 3435

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.30—0.40
Manganese	0.30—0.60
Nickel	2.75—3.25
Chromium	0.50—0.90

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1450 deg. fahr. in oil.
Drawn at 1000 deg. fahr.

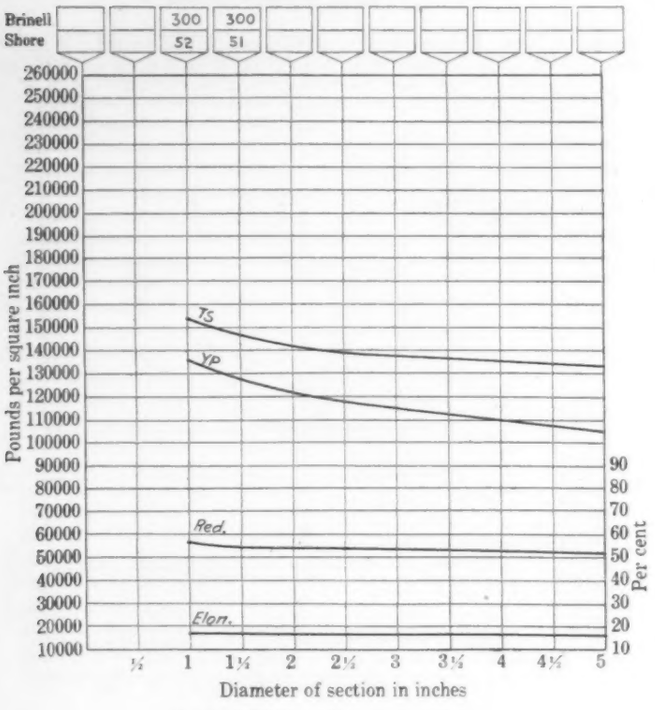
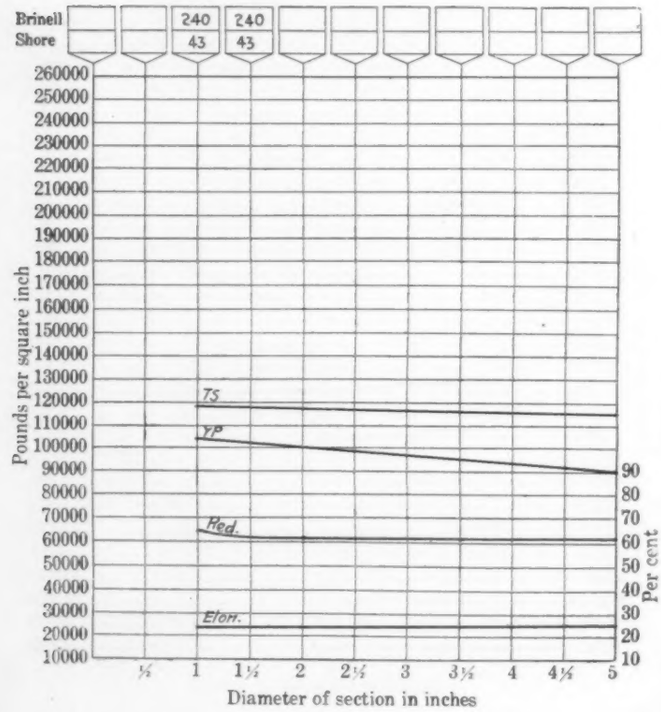


CHART FOR S.A.E. STEEL 3435

CHEMICAL COMPOSITION IN PERCENTAGE

Carbon	0.30—0.40
Manganese	0.30—0.60
Nickel	2.75—3.25
Chromium	0.50—0.90

Normalized at 1600 to 1700 deg. fahr.
Quenched at 1450 deg. fahr. in oil.
Drawn at 1200 deg. fahr.



LIGHTING DIVISION REPORT

Division Personnel

W. A. McKay, *Chairman*	Westinghouse Lamp Co.
C. A. Michel, *Vice-Chairman*	Guide Motor Lamp Mfg. Co.
A. K. Brumbaugh	Autocar Co.
J. T. Caldwell	National Lamp Works
G. P. Doll	Thomas J. Corcoran Lamp Co.
C. E. Godley	Edmunds & Jones Corporation
C. A. B. Halvorson, Jr.	General Electric Co.
J. H. Hunt	General Motors Research Corporation
A. R. Lewellen	Chevrolet Motor Co.
H. H. Magsick	National Lamp Works
W. J. Outcalt	General Motors Corporation
L. C. Porter	Edison Lamp Works
E. S. Preston	Chicago Electric Mfg. Co.
C. D. Ryder	Cincinnati-Victor Co.
A. J. Scaife	White Motor Co.
J. C. Stearns	Culver-Stearns Mfg. Co.
F. W. Todd	Accessories Mfg. Co.
T. I. Walker	Providence Base Works
E. E. Wood, Jr.	Miniature Incandescent Lamp Corporation
Ernest Wooler	Cleveland Automobile Co.

BASES, SOCKETS AND CONNECTORS

(*Proposed Revision of S. A. E. Standard*)

As a result of recent developments in the manufacture of incandescent lamp bulbs, the Lighting Division recommends that the present S.A.E. Standard for Bases, Sockets and Connectors, p. B4 of the S.A.E. HANDBOOK, be revised by increasing the distance from the contact end of the base, not including the solder, to the open end of the base 1/16 in., thus making the limits for the length of base 0.742 to 0.758 in. instead of 0.679 to 0.695 in.

To prevent the ends of the contacts on double-contact plugs from being too uneven, it is recommended that tolerances of plus and minus 0.005 in. be specified for the distance the contacts extend beyond the end of the plug, which is 1/64 in. As cap breakage has been experienced owing to the lack of a proper shoulder in the bore at the end of the threads, which permits the plugs to screw in beyond the threads and split the cap, it is recommended also that the bore diameter above the threads for single-contact plug caps only be decreased from 17/32 to 7/16 in.

NOMENCLATURE DIVISION REPORT

Division Personnel

H. L. Pope, *Chairman*	Wright Aeronautical Corporation
W. P. Kennedy, *Vice-Chairman*	Kennedy Engineering Corporation
J. B. Bartholomew	Avery Co.
W. F. Borgerd	International Harvester Co.
W. S. Bouton	Hendee Mfg. Co.
W. J. Brandon	Avery Co.
H. R. Cobleigh	National Automobile Chamber of Commerce
H. M. Crane	Consulting Engineer
W. P. Culver	American Auto Parts Co.
A. B. Cumner	Autocar Co.
L. S. Keilholtz	Delco-Light Co.
V. E. McMullen	Hercules Corporation
Leonard Ochtman, Jr.	Joseph VanBlerck Engine Corporation
W. T. Thomas	Ithaca, N. Y.
L. C. Voyles	Nordyke & Marmon Co.
L. M. Woolson	Packard Motor Car Co.

RADIATOR NOMENCLATURE

(Proposed Revision of S. A. E. Standard)

The Nomenclature Division recommends that Group 1 of Division III of the present S.A.E. Standard for Automobile Nomenclature, p. K1 of the S.A.E. HANDBOOK, be revised in accordance with the accompanying nomenclature proposed for Group 2, Radiator, and Group 3, Radiator Core.

The radiator nomenclature and definitions of the four types of core were formulated by the Radiator Division after considerable study and as a result of several meetings. The report was referred to the Nomenclature Division for coordinating with the existing nomenclature in conformity with the regular nomenclature standardization procedure.

DIVISION III, COOLING SYSTEM

Group 2—Radiator

Shell Type

Radiator core (see Group 3)
Radiator upper tank
Radiator filler-neck
Radiator inlet fitting
Radiator tie-rod fitting
Radiator overflow tube
Radiator lower tank
Radiator outlet fitting
Radiator drain-cock
Radiator anchor stud or bolt
Radiator anchor stud or bolt plate
Radiator side bolting-member
Radiator shell
Radiator supports
Radiator hinge-rod fitting
Radiator hood-ledge liner

Cast Type

Radiator core (see Group 3)
Radiator upper tank
Radiator filler-cap
Radiator inlet fitting
Radiator tie-rod fitting
Radiator overflow tube
Radiator outlet fitting
Radiator drain-cock
Radiator anchor stud or bolt
Radiator anchor stud or bolt plate
Radiator sides
Radiator clamping strips
Radiator header gasket
Radiator inlet gasket
Radiator outlet gasket
Radiator hinge-rod fitting
Radiator hood-ledge liner

Group 3—Radiator Core

Individual Fin and Tube Core.—An assembly of fluid tubes of any cross-sectional form to each of which are attached gills or fins of circular, square or other shape, each tube and its fin or fins forming a separate unit.

Continuous Fin and Tube Core.—An assembly of fluid tubes of any cross-sectional form, the tubes being joined together by radiating fins or plates common to all the tubes.

Ribbon Cellular Core.—A number of fluid passages formed by joining metal ribbons at the edges, the fluid passage walls usually being crimped and grouped to form a cellular structure. Parts of the cellular structure may be formed by flat or crimped ribbon which is not a part of the water passage.

Air Tube Cellular Core.—An assembly of air tubes nested in such a way as to form fluid passages between the tubes, the passages being sealed at the ends of the tubes. In this type the fluid may flow transversely as well as vertically around the tubes.

PARTS AND FITTINGS DIVISION REPORT

Division Personnel

W. C. Keys, *Chairman*	Gabriel Snubber Sales & Service Co.
C. R. Alling	Underwriters' Laboratories
Clarence Carson	Dodge Bros.
H. B. Garman	Garman Mfg. Co.
H. S. Jandus	C. G. Spring Co.
W. J. Outcalt	General Motors Corporation
F. W. Slack	Peerless Motor Car Co.
C. W. Spicer	Spicer Mfg. Corporation
E. W. Weaver	Weaver & Kemble Co.
F. G. Whittington	Stewart-Warner Speedometer Co.

BRAKE-LINING

(Proposed Revision of S.A.E. Standard)

The Parts and Fittings Division recommends that the present S.A.E. Standard for Brake-Lining, p. C55 of the S.A.E. HANDBOOK, be revised by the addition of the 1/4 x 4 and the 5/16 x 5-in. sizes and by the elimination of the following sizes:

5/32 x 2 1/4	5/16 x 2 3/4
1/4 x 1 3/4	3/8 x 2 3/4
1/4 x 2 1/4	3/8 x 3
1/4 x 2 3/4	3/8 x 3 1/4
5/16 x 2 1/4	3/8 x 4
5/16 x 2 1/2	3/8 x 4 1/2

The standard revised in compliance with the recommendation of the Division is given in Table 14.

It is considered that the 18 sizes of brake lining in the revised standard are required to cover the necessary range of applications. The 5/32 x 1 1/8-in. size is included as it is used extensively for motorcycles. The standard is, of course, intended for adoption in future production as changes in design permit.

The Subdivision, of which Clarence Carson, of Dodge Bros., is chairman, is also working on the standardization of brake-lining tests, much time and money having been expended in the development of several testing-machines that have been tried out by the brake-lining manufacturers and the Bureau of Standards. The work has not progressed to such a point, however, that a report can be made at this time.

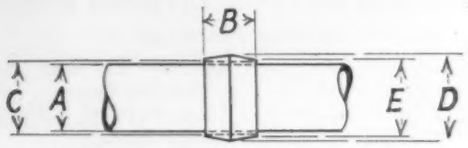
TABLE 14—PROPOSED REVISED STANDARD FOR BRAKE-LINING SIZES

Width, In. ±1/16	Thickness, In. 5/32	3/16	1/4	5/16
1 1/8	*			
1 1/4	*			
1 1/2	*	*		
1 3/4	*	*		
2	*	*	*	
2 1/4		*		
2 1/2		*	*	
3			*	*
3 1/2				*
4			*	*
5				*
Thickness Tolerances	+0.000 −0.020	+0.000 −0.020	+0.000 − 1/32	+0.000 − 1/32

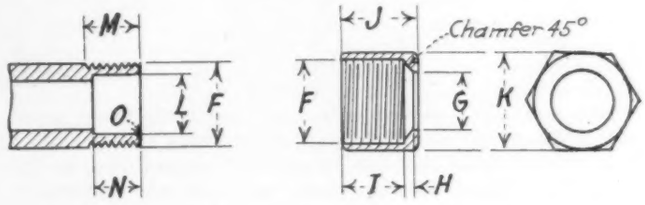
FUEL AND LUBRICATION PIPE FITTINGS—COMPRESSION TYPE

(Proposed S.A.E. Recommended Practice)

The Parts and Fittings Division recommends for adoption as S.A.E. Recommended Practice the accompanying compression-type fuel and lubrication pipe fittings. The dimensions proposed were prepared by a Subdivision consisting of W. H. Hollister, of the Imperial Brass Co., and

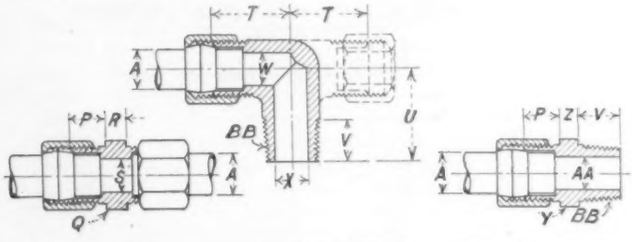


Tubing Diameter A	B	C		D	E
		Max.	Min.		
1/8	3/16	0.132	0.128	3/16	0.140
3/16	7/32	0.195	0.191	17/64	0.203
1/4	1/4	0.257	0.253	11/32	0.266
5/16	9/32	0.320	0.316	13/32	0.329
3/8	5/16	0.383	0.379	15/32	0.392
1/2	3/8	0.509	0.505	13/32	0.518



Tubing Diameter A	F*	G		H	I	J	K	L ±0.002	M Min.	N	Radius O
		Max.	Min.								
1/8	1/4–24	0.134	0.130	3/4	1/4	11/32	3/16	0.134	1/4	5/16	3/4
3/16	3/8–24	0.197	0.193	3/4	5/16	3/16	1/16	0.199	5/16	7/32	3/4
1/4	7/16–24	0.260	0.256	1/16	11/64	11/32	1/2	0.260	1/16	1/4	1/16
5/16	1/2–24	0.323	0.319	1/16	11/64	7/16	5/16	0.323	11/64	5/32	1/16
3/8	11/16–24	0.386	0.382	1/16	11/64	11/32	5/16	0.386	5/16	1/16	1/16
1/2	13/16–20	0.512	0.508	3/4	1/2	5/16	11/32	0.512	1/16	3/16	3/4

*U. S. Standard Form.



Tubing Diameter A	P	Q Hexagon Diameter	R	S	T	U	V	W	X	Y Hexagon Diameter	Z	AA	BB[1]
1/8	1/4	3/8	1/8	5/32	5/8	11/16	3/8	5/32	5/16	7/16	5/32	5/32	1/8
3/16	5/32	7/16	5/32	1/16	11/16	23/32	3/8	1/8	5/16	7/16	5/16	1/8	1/8
1/4	5/16	1/2	5/16	5/16	3/4	3/4	3/8	5/16	5/16	7/16	5/16	5/16	1/8
5/16	11/32	5/8	5/16	1/4	13/16	7/8	3/8	5/32	5/32	1/2	5/16	5/32	1/8
3/8	3/8	9/16	5/32	5/16	7/8	1	7/16	5/16	5/16	7/16	5/32	5/16	1/4
1/2	7/16	5/8	1/4	11/32	11/16	1 1/8	1/2	11/32	11/32	11/16	5/32	11/32	3/8

[1]American Standard (Briggs) Pipe Thread.

W. J. Outcalt, of the General Motors Corporation. Although the threads specified in the recommendation are S.A.E. Standard only for the 1/8 and 3/16-in. sizes, the threads recommended were selected many years ago because the coarser threads, then standard, were unsatisfactory when used in applications subject to severe vibration. Consequently any changes made in the pitches at the present time would affect the entire output of practically all of the compression-type fitting manufacturers as the dimensions proposed are practically standard at the present time.

Rod-End Pins

(Proposed Revision of S.A.E. Standard)

Since the present S.A.E. Standard for Rod-End Pins, p. C10 of the S.A.E. HANDBOOK, was adopted by the Society in January, 1915, production developments have made possible the manufacture of rod-end pins by upsetting the heads, which require slightly greater diameter tolerances.

The Parts and Fittings Division therefore recommends that the present S.A.E. Standard for Rod-End Pins be revised to specify tolerances of minus 0.002 to minus 0.007 in. for nominal diameters 3/16 to 7/16 in. inclusive and minus 0.004 to minus 0.009 for nominal diameters from 1/2 to 1 in. inclusive.

Cotter-Pins

(Proposed Revision of S.A.E. Standard)

The Parts and Fittings Division recommends that the present S.A.E. Standard for Cotter-Pins, p C7 of the S.A.E. HANDBOOK, be revised to conform to the dimensions given in Table 15. The present standard specifies that cotter-pin holes shall be drilled oversize on the basis that cotter-pins are manufactured in accordance with the nominal cotter-pin sizes. It has become general practice to produce cotter-pins smaller than the nominal size, however, and consequently the cotter-pin holes should be drilled to size.

The Division also takes this opportunity to omit all cotter-pin diameters expressed in sixty-fourths of an inch and to add the 5/32, 3/16, 7/32, 1/4 and 5/16-in. nominal sizes. In submitting this recommendation, the Division contemplates that in case the report is approved, all other S.A.E. Standards and Recommended Practices specifying cotter-pins will be brought into agreement with this proposed revision.

TABLE 15—PROPOSED STANDARD COTTER-PIN DIMENSIONS

Length, In. (L)	D—Nominal Trade Diameters, In. 1/16	3/32	1/8	5/32	3/16	7/32	1/4	5/16
5/16	*							
7/16	*							
1/2	*	*						
5/8	*	*						
3/4	*	*						
7/8	*	*	*					
1		*	*					
1 1/8		*	*					
1 1/4			*	*				
1 3/8			*	*				
1 1/2			*	*				
1 5/8			*	*	*			
1 3/4			*	*	*			
2				*	*	*		
2 1/4				*	*	*	*	
2 1/2					*	*	*	*
2 3/4						*	*	*
3						*	*	*
Actual wire diameter limits, in.:	0.061	0.090	0.122	0.150	0.176	0.207	0.225	0.280
	0.058	0.086	0.118	0.146	0.172	0.202	0.220	0.275

The Washburn and Morn steel wire gage is usually used for specifying cotter-pin wire sizes.

TABLE 16—PROPOSED FELT SPECIFICATIONS

S.A.E. Specification No.	Trade Classification	Wool, Per Cent	Ash Per Cent, Max.	Color	Thickness Tolerance, Plus or Minus, Per Cent
F1	Back Check	100	1.00	White	10
F2	Back Check	100	1.00	Any Color	10
F3	Back Check	95–100	1.25	Any Color	10
F10	Firm Pad	100	1.00	White	10
F11	Firm Pad	100	1.25	Grey	10
F12	Firm Pad	90–95	1.25	Grey	10
F13	Firm Pad	80–85	1.25	Grey	10
F15	Firm Pad	60–65	1.50	Grey	10
F26	Soft Pad	50–55	1.50	Grey	10
F30	Medium Sheet	100	1.25	White	5
F50	Colored Shoe Upper	100	1.25	All Colors[5]	10
F51	Shoe Upper	70	1.25	Grey and Black	15
F60	Asbestos[3]	50[4]	5.00	Grey	15

[3] This a trade term and does not refer to universal asbestos.
[4] 50 per cent reworked wool and 50 per cent wool substitutes.
[5] Except gray and black.

FELT SPECIFICATIONS

(Proposed S. A. E. Recommended Practice)

In the face of the wide difference of opinion as to the possibility of formulating practical specifications for felt, the Parts and Fittings Division appointed in 1920 a Subdivision on Felt which undertook the task of formulating felt specifications that would be of real assistance to engineers and purchasing agents.

A preliminary report was submitted by the Subdivision, of which H. W. Jarrow, of the American Felt Co., was chairman, and was circularized among manufacturers and users for comments, which were used as the basis in formulating the felt specifications. These were approved after being modified somewhat by the Parts and Fittings Division, and are submitted herewith for approval as S.A.E. Recommended Practice.

The result of the circular letter on felt specifications brought out the fact that the specifications were considered to be of real value to the engineering fraternity in that they establish definite specifications for a product that has hitherto been purchased by sample only.

The specifications were printed in the May issue of THE JOURNAL under the heading "Tentative Standardization Work" but no adverse comments were received from the members of the Society.

The Subdivision made an effort to develop some satisfactory method for measuring the thickness of felt but without success. The purchaser is protected, however, as the weight of the felt is definitely given in the specification.

To determine the percentage of wool, the following method abstracted from Sadtler's Industrial Organic Chemistry should be used

Boil a 2-gram sample of the material to be tested in 60 to 80 cc. of sodium-hydroxide solution of 1.02 specific gravity for 15 min., using a reflux condenser. Wash the residue with distilled water until the sodium-hydroxide and the saponified wool are removed, then press out the water, dry in air and weigh.

$$\text{Per Cent Wool} = 100\ (W - 1.05\ w) \div W$$

where

W = the weight of the original sample
w = the weight of the residue

Since hair and other animal fibers similar to wool will be saponified and included in the resulting percentage, a microscopic examination should be made of the original sample.

All of the above grades of felt shall be free from starch, glue or other similar materials.

All weights shall be based on the thickness of the felt as ordered and no correction in weight shall be made for variations in the thickness of the material received.

The appearance, hardness, and oil-absorption qualities shall be in accordance with a sample of felt approved by the engineering department and retained as a standard by the purchasing and inspection departments.

General Information.—Back check and firm pad felts are recommended for use in washers, bushings, oiling wicks, door bumpers and similar parts.

Soft pad felt is intended for chassis strips. Medium

TABLE 17—THICKNESS AND WEIGHT OF PROPOSED STANDARD FELTS

S.A.E. Specification No.	Weight of Felt, Lb. per Sq. Yd. per 36-in. Width Allowable Tolerance, Plus or Minus 10 Per Cent									
	Felt Thickness, In.									
	1/8	3/16	1/4	5/16	3/8	1/2	3/4	1	1 1/2	2
F1	2.00	3.00	3.95	5.10	6.00	8.20	....	....	....	....
F2	2.00	3.00	3.95	5.10	6.00	8.20	....	....	....	....
F3	2.00	3.00	3.95	5.10	6.00	8.20	....	....	....	....
F10	1.50	1.75	2.25	2.75	3.25	4.25	....	....	....	....
F11	1.50	1.75	2.25	2.75	3.25	4.25	....	....	....	....
F12	1.50	1.75	2.25	2.75	3.25	4.25	....	....	....	....
F13	1.50	1.75	2.25	2.75	3.25	4.25	....	....	....	....
F15	1.50	1.75	2.25	2.75	3.25	4.25	....	....	....	....
F26	1.10	1.50	1.90	....	....	....	....	....	....	....
F30	....	....	5.00	....	7.50	10.00	17.50	20.00	30.00	40.00
F50[b]	....	....	....	....	....	....	....	....	....	....
F51[c]	....	....	....	....	....	....	....	....	....	....
F60	....	....	1.50	....	2.25	3.00	4.50	6.00	....	....

[b] Specification No. F50 shall weigh 20 oz. per yd. 60. in. wide when 0.050 in. thick; 22 oz. when 0.055 in. thick; 24 oz. when 0.060 in. thick; 26 oz. when 0.065 in. thick; 28 oz. when 0.070 in. thick; 30 oz. when 0.075 in. thick; 32 oz. when 0.080 in. thick and 34 oz. when 0.085 in. thick.
[c] Specification No. F51 shall weigh 12 oz. per yd. 60 in. wide when 1/32 in. thick; 18 oz. when 3/64 in. thick; 24 oz. when 1/16 in. thick and 30 oz. when 5/64 in. thick.

sheet felt is intended for use where a felt harder than back check felt is required.

Colored shoe upper felt is intended for use for ball and roller bearing oil-retainer washers and for use where an accurate, thin, smooth, high-grade felt is desired.

Shoe upper felt is intended for use where a felt thinner than back check or pad felt is required and where the higher quality of colored shoe upper felt is not required.

Asbestos felt is intended for such applications as soft top padding or cushions.

License-Plates and Brackets

(Proposed Cancellation of S.A.E. Standard)

The Parts and Fittings Division recommends that the present S.A.E. Standard for License-Plates and Brackets, p. C56 of the S.A.E. Handbook, be cancelled as it has become obsolete through development in license-plate design since the standard was approved in 1916.

The Division is considering the advisability of recommending standard dimensions for the location of the slot in the license-plate bracket which will permit the greatest possible variation of the position of the holes in the license-plates in line with the specifications incorporated in the Massachusetts State law.

Taper Fittings with Plain or Slotted Nuts

(Proposed Extension of S.A.E. Standard)

As the Motorboat Division desired to extend the present standard for motorboat couplings to include the sizes most generally used in present practice, the Parts and Fittings Division was asked to supply the dimensions for taper fittings for the 1⅝, 1⅞ and 3¼-in. nominal shaft-diameters, which are not included in the present S.A.E. Standard for Taper Fittings with Plain or Slotted Nuts.

The dimensions given in the accompanying table were submitted by C. W. Spicer, who formulated the original taper and spline-fitting standards, and were approved by the Division and transmitted to the Motorboat Division for use in the motorboat coupling standards. The Parts and Fittings Division therefore recommends that the dimensions given in Table 18 be adopted as an extension of the present S.A.E. Standard for Taper Fittings with Plain or Slotted Nuts, p. C14 of the S.A.E. Handbook.

TABLE 18—DIMENSIONS FOR TAPER FITTINGS WITH PLAIN OR SLOTTED NUTS

Nom. Diam.	Shaft D_s Max.	Shaft D_s Min.	Diam. of Hole D_h Max.	Diam. of Hole D_h Min.	L_e	L_s	L_h	L_t	D_t	Threads, per In.	T_s	T_p
1⅝	1.626	1.624	1.622	1.620	2 11/32	2 1/4	2 1/4	11/32	1 1/4	18	5/8	7/32
1⅞	1.876	1.874	1.872	1.870	3 1/32	2 5/8	2 1/2	11/32	1 1/4	18	5/8	7/32
3¼	3.252	3.248	3.245	3.242	5 7/32	4 1/8	4 1/4	1 1/4	2	16	1	9/32

Nom. Diam.	Width Across Flats of Nut	W Max.	W Min.	H Max.	H Min.	Square Key Max.	Square Key Min.	C
1⅝	2 3/16	0.4375	0.4365	0.2242	0.2217	0.4390	0.4380	1/2
1⅞	2 3/16	0.4375	0.4365	0.2242	0.2217	0.4390	0.4380	1/2
3¼	3 5/8	0.7500	0.7485	0.3900	0.3850	0.7520	0.7505	5/8

For reference letters, see p. C14 of the S. A. E. Handbook.

TRUCK DIVISION REPORT

Division Personnel

A. J. Scaife, *Chairman*	White Motor Co.
J. R. Coleman, *Vice-Chairman*	Selden Truck Corporation
A. K. Brumbaugh	Autocar Co.
F. W. Davis	Consulting Engineer
H. E. Derr	International Harvester Co.
J. C. Haggart, Jr.	Republic Motor Truck Co.
A. W. S. Herrington	Quartermaster Corps
M. C. Horine	International Motor Co.
E. A. Kingsbury	Sanford Motor Truck Co.
H. B. Knap	Packard Motor Car Co.
J. A. Kraus	Garford Motor Truck Co.
W. M. Petty	Service Motor Truck Co.
F. A. Whitten	General Motors Truck Co.

Motor-Truck Cabs

(Proposed S.A.E. Recommended Practice)

In 1921 the Truck Division was asked to consider the possibility of standardizing motor-truck cabs as it was recognized that conditions in the industry made it impossible for cab manufacturers to use quantity-production methods, the general practice being to sell the chassis without cabs, these being obtained by the chassis purchasers at additional expense and loss of time. As the Truck Division had recommended standard motor-truck body-installation dimensions, which had been adopted by the Society, it was considered desirable to continue this work to establish the necessary dimensions for obtaining interchangeabilities of cabs.

Information was therefore obtained from the motor-truck builders as to their cab-mounting dimensions, the consensus of opinion of the companies being that cab standardization was desirable. It was recognized, however, that no recommendation of the Division should limit truck design in any way.

As a result of the information obtained, a tentative recommendation was submitted for general comment by the Truck Division in September, 1922. As the comments received indicated further revisions were desirable, the recommendation was further revised and again submitted for comment in October of the same year. At the January Society Meeting in 1923 the Division reviewed the comments that had been received and although it was recognized that the recommendation was fundamentally right, it was considered that final action should not be taken on the proposal until the cab manufacturers and users had had an opportunity to discuss the recommendation at an open meeting. Such a meeting was held in Detroit in March, 1923, the tentative recommendation having been circularized again in the meantime, and the comments being discussed in detail at the meeting.

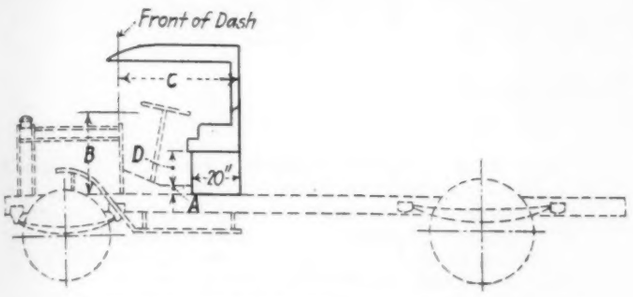
As it was possible to obtain definite agreement at this meeting, the Truck Division recommends for adoption as S.A.E. Recommended Practice the accompanying cab dimensions and also recommends that the accompanying paragraphs be included with the recommendation as "General Information Only." At the meeting in March the original recommendation was extended to include cabs intended for "speed-wagons," as it was felt that practice was sufficiently established to specify definitely mounting dimensions for such cabs.

Subsequent to the last meeting, the recommendation as submitted herewith was referred to motor-truck and motor-truck cab manufacturers for final comment. The replies received were favorable to the present recommendation and the Division feels confident that in submitting the accompanying proposal it is meeting the wishes of the entire motor-truck industry.

GENERAL INFORMATION

The filler-pipe should be of the flush type and located at least 6 in. from the center of the fuel tank.

When it is desired to provide a space under the seat for the storage-battery and the tool-boxes, a square fuel-tank should be used.



Truck Capacity, Tons	A	B[1] Max.	C	D	
				Max.	Min.
1½ and Under	2	28	46	13	10
1½ and Over	3½	36	46	15½	13½

[1] Dimension *B* is from the top of the chassis frame to the top of the highest dash that can be accommodated.

As it is difficult to design practical cabs when extremely wide dashes are used, the maximum dash-width should be 44 in. for all trucks of 1½ tons capacity or larger. For trucks of smaller capacity, the maximum dash-width should be 37 in.

STATIONARY-ENGINE DIVISION REPORT

Division Personnel

L. F. Burger, *Chairman*	International Harvester Co.
C. B. Segner, *Vice-Chairman*	Domestic Engine & Pump Co.
H. G. Holmes	Novo Engine Co.
V. E. McMullen	Hercules Corporation
T. C. Menges	Associated Manufacturers Co.
I. J. Nelson	Nelson Bros.
O. A. Powell	Cushman Motor Works
L. W. Witry	Waterloo Gasoline Engine Co.

STATIONARY-ENGINE CRANKSHAFTS

(*Proposed Cancellation of S.A.E. Recommended Practice*)

In April, 1921, the Stationary-Engine Division approved a series of crankshaft and crank-pin diameters which was adopted by the Society in July, 1921, and printed on p. A29 of the S.A.E. HANDBOOK. As a result of several votes cast against this recommendation by the Society members, the Council requested the Division to reconsider it. As subsequent consideration indicated that there is too great a variation of engine sizes and designs to permit practical standardization of crankshafts and crank-pin diameters, the Stationary-Engine Division recommends that the original recommendation of the Division be cancelled.

STATIONARY-ENGINE BELT-SPEEDS

(*Proposed S.A.E. Recommended Practice*)

In 1921 the Stationary-Engine Division recommended the adoption as S.A.E. Recommended Practice of a series of stationary-engine belt-speeds. This commendation was, however, criticized adversely by members of the Society and referred back to the Division by the Standards Committee for further study.

This subject has received further consideration by the members of the Stationary-Engine Division as the result of which the accompanying table of belt speeds is recommended for adoption as S.A.E. Recommended Practice. It is felt that the recommendation will provide information to engine builders as well as power-driven equipment manufacturers which should be used in designing new apparatus to obtain the proper operation of farm equipment.

TABLE 19—STATIONARY-ENGINE BELT-SPEEDS

Rated Engine Power, Hp.	Belt Speed, Ft. per Min.
1½	600
2	750
3	950
4	1,125
5	1,275
6	1,400
7	1,500
8	1,600
9	1,650
10	1,700
12	1,800
15	1,900

The belt speeds for *portable* engines of 10 hp. and larger shall be 2600 ft. per min., tractor belt-speed standard.
The variation in belt speeds shall not exceed 5 per cent above or below those specified.

EVOLUTION

AN engineering designer above all people should proceed along the path of progress by short and well comprehended steps. There should be no leaps in the dark. A slight change of detail in a mechanism frequently results in a performance or symptom that was not anticipated. Such a change may bring a result out of all proportion to the amount of the alteration made. Obviously, therefore, if a number of new, though comparatively small, changes are carried out simultaneously, the diagnosing or rectifying of more than one defect or trouble at a time may well prove to be a very complex and costly process. One experiment at a time should be an invariable rule.

A further point in connection with design is the apparent distaste of the purchasing public for goods that they may consider too novel. Objections on this point frequently hold good even in the case of articles that have been proved to be of greater efficiency and even of less cost than those produced to more conventional designs. To some extent this viewpoint is justified. For example, practically every adult residing in a civilized country comprehends, at least in some measure, the main features of the modern motor-car. As untrained minds often find considerable difficulty in grasping the technicalities of new mechanisms, motor-car designers are wise in adhering to what are considered orthodox general arrangements.

The all-important matter of cost also enters largely into any question as to the advisability of producing entirely new designs. Apart from the very considerable sums that must be expended on special tools, jigs, gages, etc., it is necessary to bear in mind that it requires some time for machine operators, fitters and assemblers to become thoroughly accustomed to new work. The more specialized the class of labor employed, the more serious does this consideration become. In other phases of works administration, drastic changes are likely to bring disastrous results. Many such instances come to mind. Systems require very careful handling both when they are being installed and when changed. Their apparent complexity when viewed for the first time as a whole is due, as a rule, to their gradual growth, and organizers, designers and others should take a lesson from nature and recollect that "Rome was not built in a day."—*Engineering Production* (London).

Steel[1]

By Dr. John A. Mathews[2]

BY many, the capacity for hardening in water has been considered as the distinguishing characteristic of steel. By others, it is considered that the preparation of this form of iron by a melting process is essential to distinguish steel from the other forms of iron, the result of melting the raw materials being largely to free them from the slag and the inclusions that are characteristic of wrought iron. The third quality generally considered as necessary is that of malleability. This distinguishes steel from cast iron. It is my opinion that the two really essential characteristics are manufacture by melting and the quality of malleability. It seems to me that the property of hardening should not be considered an essential of the definition. There was a discussion a few years ago as to whether the name *ingot iron* was the proper one to describe a well-known American product. This should be called *ingot steel*. It is extremely low in carbon and will not harden in the ordinary sense of the word by quenching in water. Nevertheless it is manufactured by melting in the open-hearth furnace and is malleable. It is free from slag and inclusions, and therefore should not be called iron, thereby likening it to wrought iron that has not been produced by a melting process, is not free from slag and inclusions, but is, of course, malleable. Hardening is a question of degree and the degree of hardening increases directly with the carbon-content. While a steel extremely low in carbon does not harden very materially as measured by the scleroscope and Brinell tests, such carbon as it possesses may be converted into the martensitic state by heating to a high temperature followed by a quick cooling. It may, therefore, be said to have been hardened, even though the physical hardness may not be materially increased, owing to the small amount of carbon. The martensitic form characterizes hardened steel, but the small amount of martensite is contaminated with so much free ferrite, which does not harden, that the final product will be physically soft.

In my opinion, steel as we now know it, the steel of commerce, made in Bessemer, open-hearth, crucible or electric furnaces, is that form of iron which has been produced by melting to yield a finished product that is malleable. The question of carbon-content and the incidental presence of other elements is not vital to the definition. When we wish to refer to steel of centuries prior to the invention of crucible cast-steel we may still use the term "steel" prefixed by "cemented," "blister," "shear" or "double shear." These forms of steel have continued at a diminishing rate of production down to the present time. Steel, as we know it today, began with the invention of cast steel made by a process of fusing, thereby eliminating slag and producing a practically homogeneous product in which the carbon and other elements were distributed uniformly throughout the product. The product was also malleable and therefore within the definition of steel based upon fusion and malleability. Steel prior to this time was produced without fusion, by the process of carbonizing wrought iron.

As to the use of the word *carbonize* and *carburize*, our metallurgists in general prefer the word *carburize* to indicate the process of adding carbon to low-carbon iron or steel products. I am inclined to use the word *carburize* in connection with the process of adding carbon to the molten products of open-hearth, electric or Bessemer furnaces. Carbon is added to molten steel in the form of anthracite coal, charcoal, ferromanganese and similar substances. Sometimes the process is carried out in the furnaces and sometimes in the ladles. The process of adding carbon to solid steel, as in the case-hardening operations, I am disposed to call *carbonizing*. Therefore, the old process of making a cemented steel would be considered a carbonizing process, the bars of wrought iron being packed in charcoal and subjected to heat for a period of 7 to 12 days in furnaces looking more or less like pottery kilns. The same word would apply to the modern practice of case-hardening small finished parts, such as gears.

It has been recognized for nearly 150 years that carbon is the element that confers on iron its wide variety of properties. When, in definitions of steel, carbon is included as an essential, it is generally stated that the carbon-content may vary from 0.10 to 2.00 or 2.25 per cent. The ordinary steel of commerce is well within these ranges. The true upper limit, however, is the limit of forgeability. Plain carbon-steels containing as high as 2.50 per cent of carbon can be forged with difficulty. The principal difficulty in forging the extremely high-carbon steels arises from the tendency of the excess cementite to break down into ferrite plus free graphitic-carbon. Certain elements tend to keep the carbon in combination and certain other elements tend to precipitate the free carbon in high-carbon steels. Manganese and chromium are the principal elements that tend to keep it in combination, while silicon and nickel tend to precipitate free carbon. In the carbonizing of steel the same elements act the same way; high chromium and manganese seem to facilitate the absorption of carbon, while silicon and nickel tend to retard its absorption.

In addition to the iron and carbon present in all commercial steels, there are four other elements ordinarily present whose effects must be considered. They are manganese, phosphorus, sulphur and silicon. These are often considered as impurities, since it is almost impossible to make steel free from them. The first two elements, however, especially manganese, must be considered essential and beneficial, while phosphorus and sulphur are nearly always undesirable. Copper and arsenic are usually present in minute quantities and, in the amounts ordinarily present, their effects are negligible. Aluminum is normally present not for the reason that it cannot be eliminated, but because it is added to the steel during casting and traces of it may be found in the finished product. Ordinary steel, then, by whatever process made, may contain carbon and manganese from 0.10 to 1.50 per cent; silicon from a trace to 0.25 per cent; phosphorus and sulphur from below 0.01 to 0.10 per cent; with copper, aluminum and arsenic in negligible quantities. Steel usually contains hydrogen, oxygen, nitrogen and cyanides in minute quantities that are not readily determined. Nevertheless, we must assume that each and all of these elements exert some influence in regard to the final quality of the steel. We have much to learn as to just how they act and as to what their influence is, particularly in regard to tool steel. It so often happens that two samples of steel, of practically identical analyses as far as the ordinary elements are determined, give such different service that we are forced to the conclusion that other factors than those that our present methods of investigation deal with control the ultimate quality. The mysterious something called quality is frequently called by the British *body*. Just what body is, I have never seen defined.

The term *alloy steel* has acquired a special significance, meaning any steel to which, in addition to carbon and iron and the impurities common to all steel, a metal or metalloid has been added to change or improve the natural properties. Chemically pure iron may be classed among the rare metals.

In general, it may be said that the influence of other elements upon an iron-carbon alloy is

(1) To change the temperature of the occurrence of the critical points

(*Concluded on p.* 609)

[1] From a paper presented before the New York Chapter of the American Society for Steel Treating.

[2] M.S.A.E.—President, Crucible Steel Co. of America, New York City.

Nebraska Tractor-Test Analysis

By Oscar W. Sjogren[1]

Chicago Tractor Meeting Paper *Illustrated with* Charts

A COMPILATION of all results of the tractor-testing work at the University of Nebraska is presented by the author, who specifies the equipment used and discusses the subjects of the proper rating of tractors, belt speeds, weight distribution, tractive efficiency, wheel slippage, piston displacement, fuel and water consumption in considerable detail supplemented by illustrations. The defects of tractors are divided into the three main groups of engine, accessory and chassis, and enumerated, comment being made thereon.

Three general recommendations for remedying these defects are stated and a statistical record of the results secured during the three seasons when the tests were conducted is included. That a better product is one of the direct results of the testing program is indicated by the statistics presented in Table 1.

THIS paper states the results of an extensive but by no means exhaustive study of the data secured in the tractor-testing work at the University of Nebraska. These data are so inclusive that even an extensive study of them cannot exhaust the possible different angles of attack. The data given are a compilation of all results. All comparisons made are based on actual performance records, and not on any personal preferences. The Nebraska tests are all carried out under as nearly similar conditions of operation as it is possible to secure, which fact makes an analysis of the results of more than ordinary value. The figures for the 1922 tests are not included in this study except where mentioned.

All belt tests were made on a Sprague electric dynamometer driven by belting the tractor to it with a belt of width and length as recommended for use with the tractor in ordinary operation. No allowance was made for belt loss, as it was contended that it is the power delivered to the driven machine that is to be considered in actual operation. The drawbar tests were run on a ½-mile track, which has been wrongly termed a cinder-track. It is true that cinders were used, but only to the extent of a thickness of about 2 in. mixed into the upper 8 in. of soil to improve drainage conditions.

Rating of Tractors

One of the outstanding discrepancies in the tractor field is the lack of standard methods of rating, in the belt and at the drawbar. For purposes of comparison, the table of rating shown in Fig. 1 was made up, in which the rated power is taken as 80 per cent of the maximum for both belt and drawbar. This shows that only 15 out of 76 tractors met this requirement on the belt, and 61 are rated above this. Seven of these were rated at a figure that they could not reach. On the drawbar, a much more liberal allowance is made as is indicated by the ratings in Fig. 2. Fifty-one tractors came up to or exceeded the 80-per cent rating, and 22 failed to reach it. Of these, two were rated at more than they could actually develop.

As measured by this standard, the ratings of a large

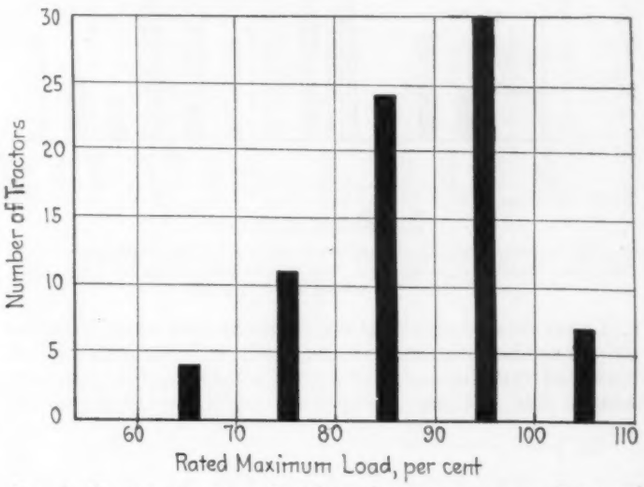


Fig. 1—Classification of Tractors According to the Relation between the Rated and the Maximum Belt Horsepower

percentage of the tractors are made on too narrow margins; very little if any allowance is made for individual differences in machines, or for possible power reductions as the tractor becomes worn. In several cases, tractors of different makes using the same kind and size of engine have been given ratings of wide variation. Three cases are cited, as follows:

(1) Four tractors of different make using the same engine are rated from 30 hp. at 900 r.p.m. to 35 hp. at 850 r.p.m., an increase of 16 per cent in rating with a 5½ per cent drop in speed

(2) Two tractors of different make using the same engine are rated at 20 and 25 hp., respectively, at the same number of revolutions per minute, a difference of 25 per cent

(3) Three tractors of different make using the same engine are rated at 12 hp. at 1000 r.p.m.; 10 hp. at 1000 r.p.m.; and 10 hp. at 1200 r.p.m.

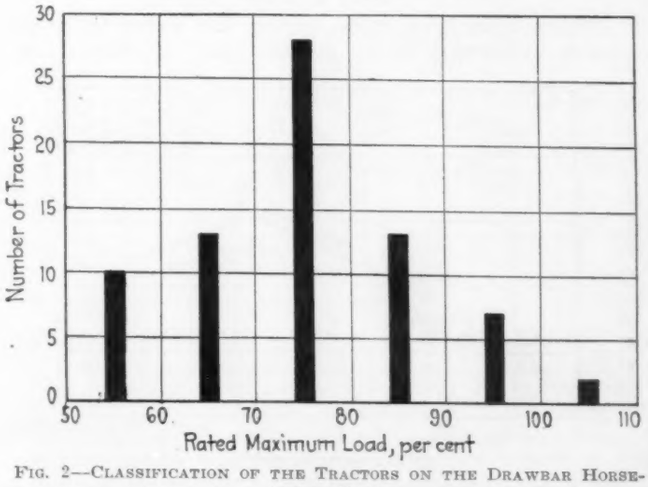


Fig. 2—Classification of the Tractors on the Drawbar Horsepower Basis

[1] M.S.A.E.—Professor of agricultural engineering, college of agriculture, University of Nebraska, Lincoln, Neb.

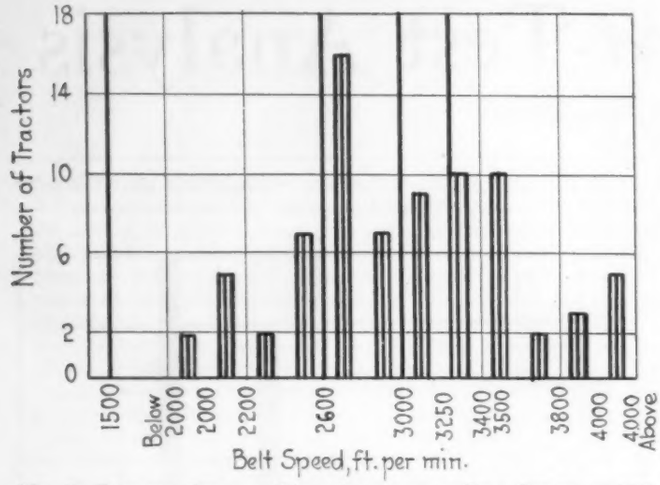


FIG. 3—DIAGRAM SHOWING HOW CLOSELY THE BELT SPEEDS OF THE TRACTORS TESTED CONFORM TO THE STANDARD RATES OF 1500, 2600, 3000, 3250 AND 3500 R.P.M.

These cases are sufficient to indicate a condition the existence for which there is no legitimate reason. A standard method of rating, conscientiously observed, would give a direct comparison of tractors from the

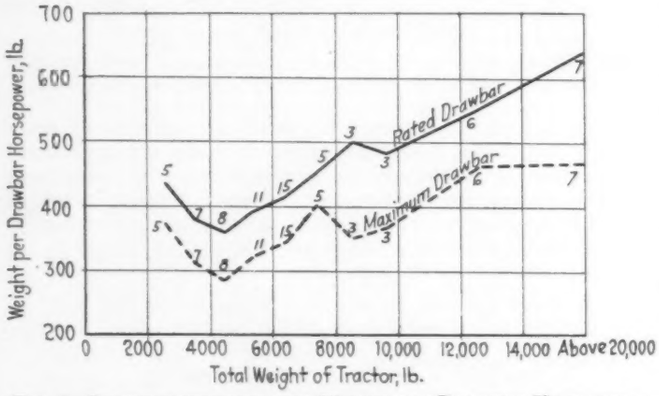


FIG. 4—RELATION BETWEEN THE WEIGHT PER DRAWBAR HORSEPOWER AND THE TOTAL WEIGHT OF THE WHEELED TYPE TRACTORS

power standpoint. This would tend to give prospective users greater confidence in the tractor industry, if they can be made to see and realize that all tractors similarly rated can be compared from the basis of power output.

BELT SPEEDS

Efforts have been made during late years to secure greater uniformity in the surface speed of tractor belt-

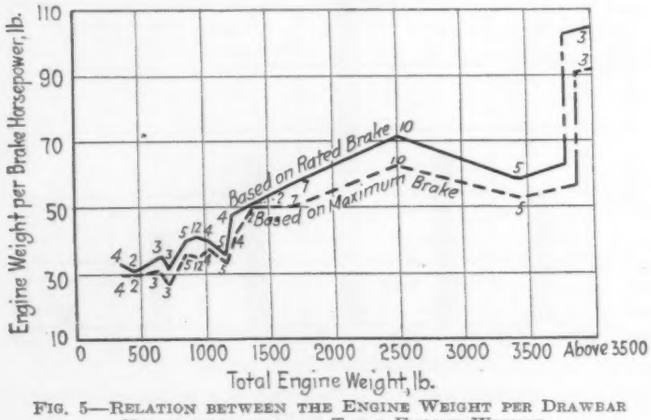


FIG. 5—RELATION BETWEEN THE ENGINE WEIGHT PER DRAWBAR HORSEPOWER AND THE TOTAL ENGINE WEIGHT

pulleys. Belt speeds of 1500, 2600, 3000, 3250 and 3500 ft. per min. have been designed as standard. Fig. 3 indicates how nearly present belt speeds conform to these standards. The heavy single lines indicate the figures adopted as standard. Here it seems is a place for great improvement. Why have so many different belt speeds? It evidently adds confusion. Possibly, wide limits are desirable when a standard is first proposed, but is it not time now to choose one or two definite belt speeds and to equip all machines with pulleys

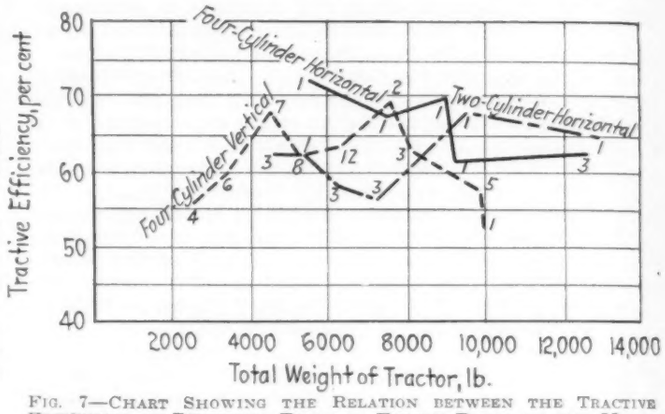


FIG. 7—CHART SHOWING THE RELATION BETWEEN THE TRACTIVE EFFICIENCY OF DIFFERENT TYPES OF ENGINE BASED ON THE MAXIMUM HORSEPOWER AND THE TOTAL WEIGHT OF THE TRACTOR

that will give these speeds at the rated number of revolutions per minute?

WEIGHT DISTRIBUTION

Upon first thought, one might easily assume that the very light tractors have less weight per drawbar horsepower than the heavier ones. However, the figures show clearly that this is not true. As given in Fig. 4, they indicate that the tractors having a total weight of about 4500 lb. have less weight per drawbar horsepower than either the lighter or the heavier ones. This relation

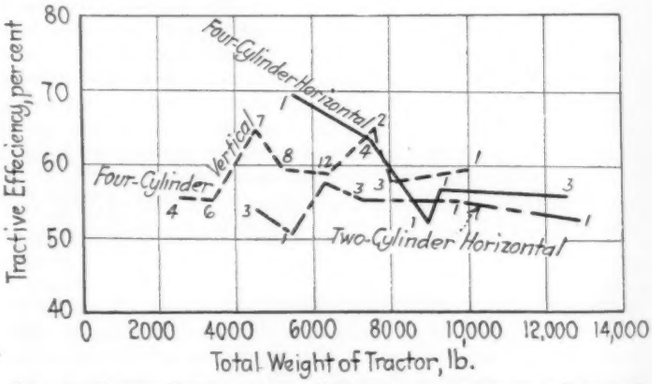


FIG. 6—CHART SHOWING THE RELATION BETWEEN THE TRACTIVE EFFICIENCY OF DIFFERENT TYPES OF ENGINE AND THE TOTAL WEIGHT BASED ON THE RATED HORSEPOWER

should be borne in mind later when making other comparisons. As is evident in Fig. 5, the general trend of the relation of total engine-weight and engine weight per brake horsepower indicates that the weight per horsepower increases as the total engine-weight increases. The three tractors represented in the lowest figure have a total average tractor-weight of 4060 lb.

TRACTIVE EFFICIENCY

The term tractive efficiency is applied to the ratio, or the percentage, of the brake horsepower delivered to

the drawbar; it is E = (Drawbar Horsepower/Brake Horsepower) x 100. Fig. 6 indicates the relation existing between total tractor-weight and tractive efficiency for the different types of engine. Here the 4500-lb. tractor is again to the front as it is in weight distribution, in that it has the highest efficiency in its class, except in the case of the tractor with a four-cylinder vertical engine. The other high point in this curve for a 7500-lb. tractor is obtained from the records of

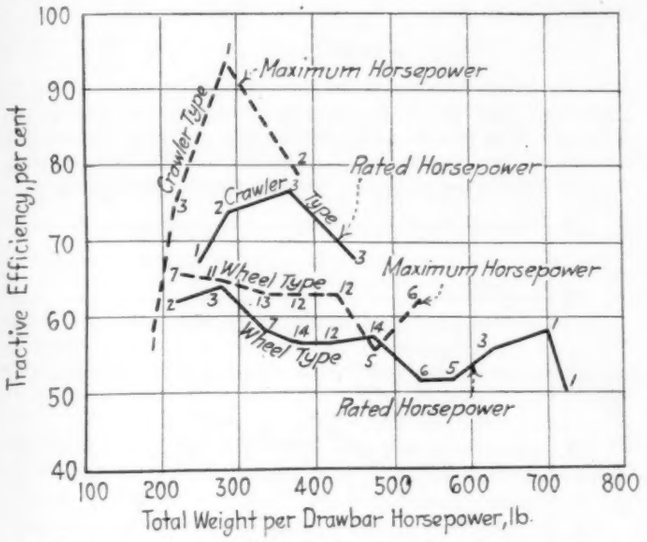


FIG. 8—RELATION BETWEEN THE TRACTIVE EFFICIENCY AND THE WEIGHT PER DRAWBAR HORSEPOWER FOR DIFFERENT TYPES OF TRACTOR

only two machines; it cannot be considered as conclusive as the point for the 4500-lb. weight, which is obtained from the records of seven machines. The points on the curve for the four-cylinder horizontal engine contain,

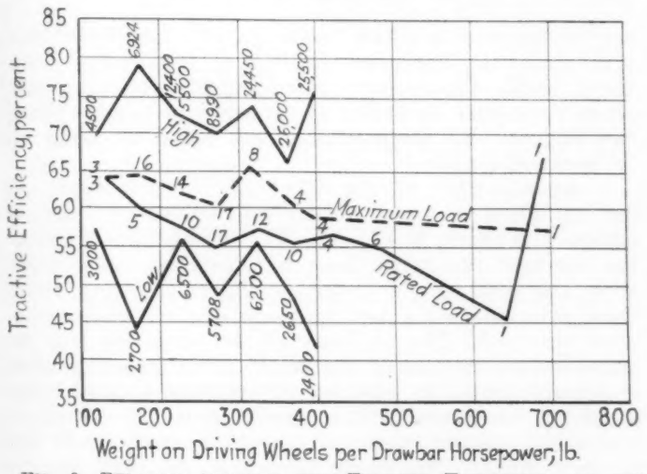


FIG. 9—RELATION BETWEEN THE TRACTIVE EFFICIENCY AND THE WEIGHT ON THE DRIVING WHEELS PER DRAWBAR HORSEPOWER

with one exception, the records of only one machine. Likewise, the curve for two-cylinder horizontal engines cannot be considered as an average. However, the general trend is noted to be toward a reduction in the tractive efficiency with an increase in the total weight of tractor beyond the 4500-lb. weight. There seems to be also a tendency toward a decreased efficiency with tractors lighter than about 4000 lb. Fig. 7 indicates that the tractive efficiency based on the maximum tests runs in much the same general trend as on the rated tests.

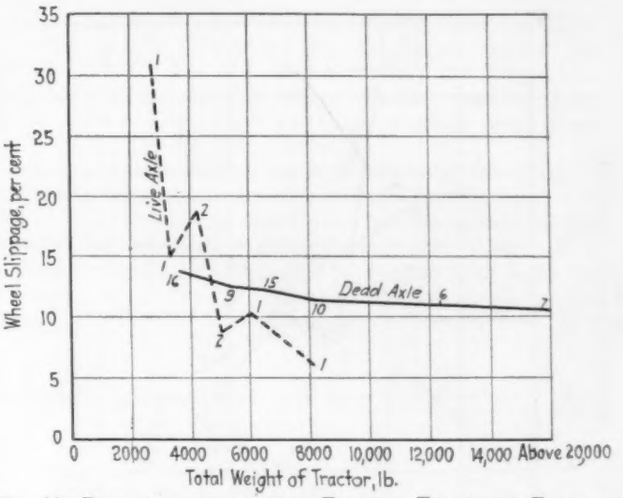


FIG. 10—RELATION BETWEEN THE TRACTIVE EFFICIENCY BASED ON THE MAXIMUM HORSEPOWER AND THE TOTAL WEIGHT OF THE TRACTOR ACCORDING TO THE TYPE OF FINAL DRIVE

With the wheel tractor, the efficiency tends to become lower as the total weight per drawbar horsepower increases, as shown in Fig. 8. The crawler type shows higher efficiency than the wheel type, but the number

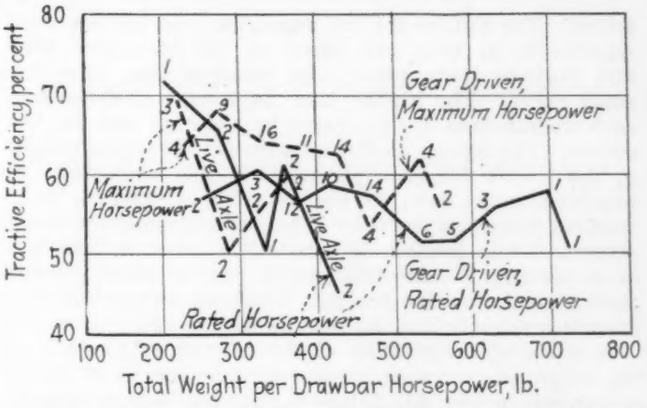


FIG. 11—RELATION OF THE TRACTIVE EFFICIENCY AND THE WEIGHT PER DRAWBAR HORSEPOWER FOR DIFFERENT TYPES OF FINAL DRIVE

of records available of this type makes it difficult to state correctly the general relation of the two factors considered. As indicated in Fig. 9, the general tendency is for the tractive efficiency to vary in an inverse ratio to the weight on the drivers per drawbar horse-

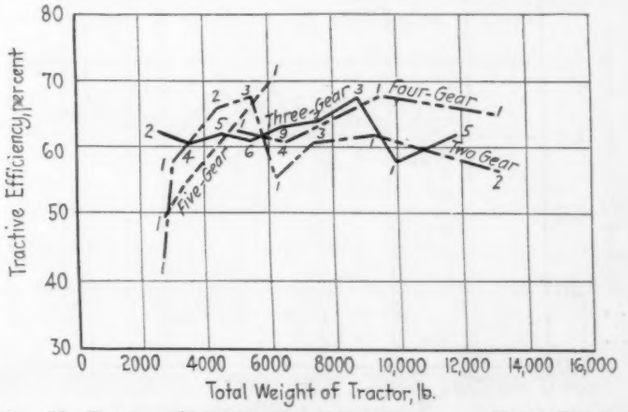


FIG. 12—TRACTIVE EFFICIENCY AS RELATED TO THE TOTAL WEIGHT OF THE TRACTOR CLASSIFIED ACCORDING TO THE NUMBER OF GEAR REDUCTIONS

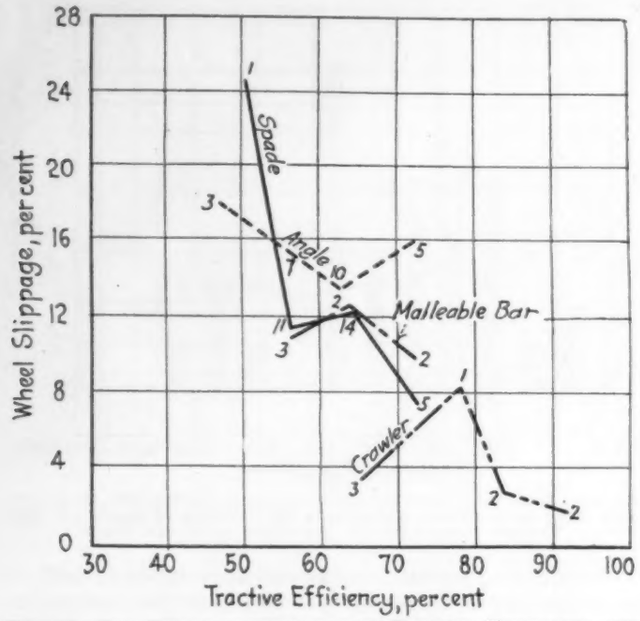


FIG. 13—THE RELATION BETWEEN THE TRACTIVE EFFICIENCY AND THE MAXIMUM WHEEL SLIPPAGE WITH DIFFERENT TYPES OF LUG

power. The figures for the maximum load are the most significant, as they are based on the maximum tests and indicate more nearly the relation than does the rated curve. The highest and the lowest efficiencies in each weight class are indicated by the high and the low curves. The figures on these curves give the total weight of the tractor for each point. It is thus seen that the heavier tractors have the highest efficiency and the light tractors have the lowest. When considering the total weight of the tractor, however, this relation does not hold. In Fig. 10, the efficiency is seen to reach its apparent maximum for tractors weighing about 5000 lb., dropping slightly for the heavier machines.

A study of the relation of the tractive efficiency and the weight per drawbar horsepower, the results of which are shown in Fig. 11, indicates that the lightest-weight tractors are not so efficient as those of medium weight, except in the case of the live-axle-driven machines. The advantages of the live-axle-driven tractor are apparent only in the lightest weights. "Live axle" is the term used when the axle is keyed or fastened rigidly to the drive-wheels and is driven from a differential. The slight

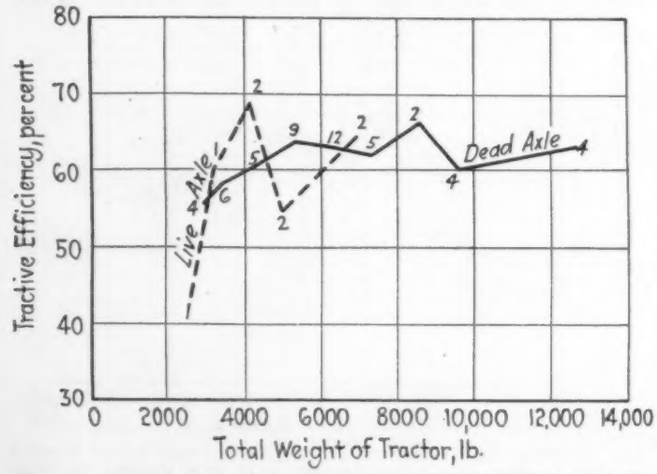


FIG. 14—WHEEL SLIPPAGE AS RELATED TO THE TOTAL WEIGHT OF THE TRACTOR CLASSIFIED ACCORDING TO THE TYPE OF FINAL DRIVE

advantage of the gear drive over the live-axle drive shown in these curves may be due to the greater number of machines in the gear-drive class on which data are available.

Some discussion has been heard in various tractor meetings about the probable effect of the number of gear reductions on the tractive efficiency. A study of the data reveals average conditions, as indicated in Fig. 12, that no one number of gear reductions has the advantage with respect to tractive efficiency.

WHEEL SLIPPAGE

One of the factors in tractor operation that seems to give considerable trouble is that of slippage of the drive-wheels. The power available at the drawbar is limited by one of two factors: (*a*) inability of the drive-wheels to maintain a grip on the ground firmly enough to pre-

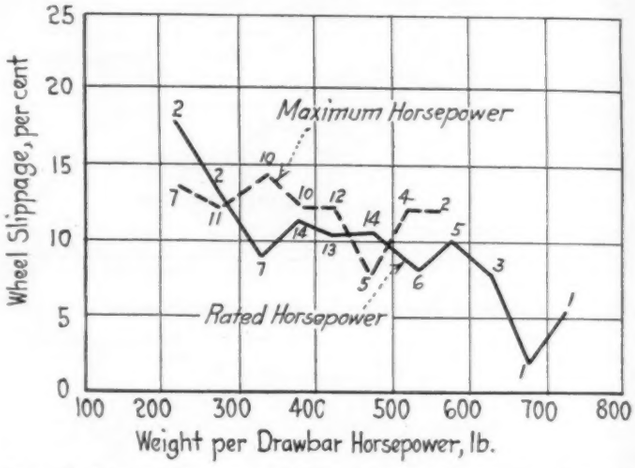


FIG. 15—IN GENERAL THE WHEEL SLIPPAGE TENDS TO DECREASE SLIGHTLY AS THE WEIGHT OF THE TRACTOR PER DRAWBAR HORSEPOWER INCREASES

vent slippage with heavy loads, or (*b*) insufficient engine power evidenced by stalling of the engine with heavy loads. Considerable effort and thought have been given by tractor designers in attempts to balance these two factors. All slippage data are taken as being at the point of a lug.

A consideration of the effect of different types of lug on wheel slippage for various values of tractive efficiency is shown in Fig. 13. The lug equipment showing the best results in these tests will not necessarily show the best results under conditions differing from those existing on the testing track where these results were obtained. The tendency of the angle lug was to pulverize the surface of the track, after traveling over it several times, to such an extent that a good grip could not be secured. This condition would not arise where the tractor breaks a new path continuously as in farm work. The spade lugs gave the best results on the track, due largely to the fact that they would penetrate the ground to a sufficient depth to give a good grip and therefore would not cut or pulverize the surface. The malleable-bar lugs were used on the largest tractors which, in themselves, were heavy enough to cause the wheels to grip the ground. It is doubtful if this type of lug would give any better results on the light tractor than did the angle lugs. The crawler-type tractors show a very low percentage of slippage, as would be expected.

Fig. 14 shows that as the total tractor-weight increases the percentage of slip of the drive-wheels de-

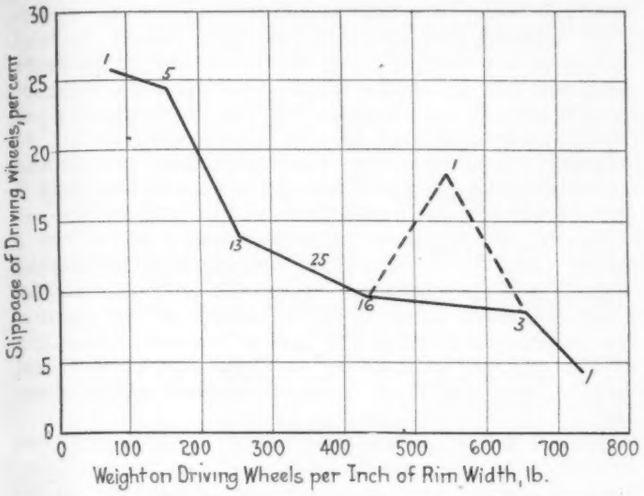


FIG. 16—DRIVING WHEEL SLIPPAGE AS RELATED TO THE WEIGHT PER INCH OF WIDTH OF THE DRIVING-WHEEL RIMS

creases slightly. The better showing made by the dead-axle type probably is due to two conditions: the larger number of machines of this type from which data could be obtained, and the fact that the heavier machines which, because of their weight, tend to have a lower percentage of wheel slippage, were also of this type. Fig. 15 indicates in a general way the tendency of wheel slippage to decrease slightly as the tractor weight per drawbar horsepower increases. This tendency to de-

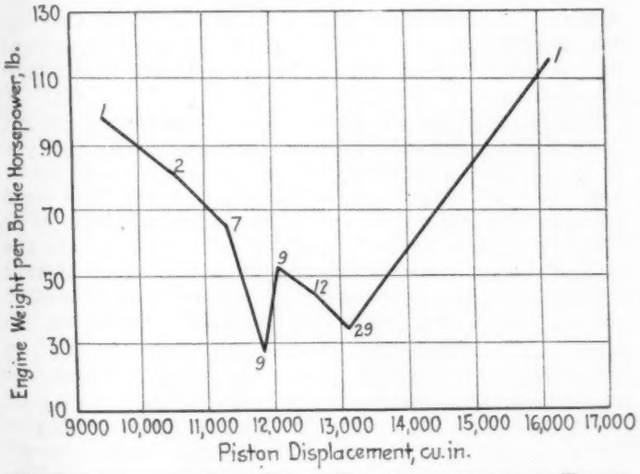


FIG. 17—RELATION BETWEEN PISTON DISPLACEMENT AND THE ENGINE WEIGHT PER MAXIMUM DRAWBAR HORSEPOWER

crease is more marked in Fig. 15 than in Fig. 14. Very many factors enter into the problem of wheel slippage, and many studies have been made of various combinations of the data, bringing into consideration the diameter of the drive-wheels, the speed of travel, the drawbar pull and the horsepower. No general tendency of the effect of these factors could be noted. Fig. 16 indicates the factor that gave the most consistent results. If all operating and soil conditions could be kept constant, no doubt some rules or some formula would be discovered that would aid materially in the design of tractors to overcome the tendency of the drive-wheels to slip under a heavy load.

Wide differences of opinion exist among tractor men as to the advantages and disadvantages of rating tractors on a piston-displacement basis. The discussion by those favoring this method of rating seems to center about the figure of 13,000 cu. in. per min. per hp. The data show a great variation in this factor among the tractors tested. Fig. 17 indicates that the large majority of tractors have a piston displacement ranging from a little above 11,000 cu. in. to slightly more than 13,000 cu. in. per min. per hp.

How the piston displacement varies with the type of engine and the engine speed is shown in Fig. 18. The evidence here is to the effect that the designers of the four-cylinder vertical engines have come closer to a standard design of performance of engine than have the designers of horizontal engines. Upon a closer ex-

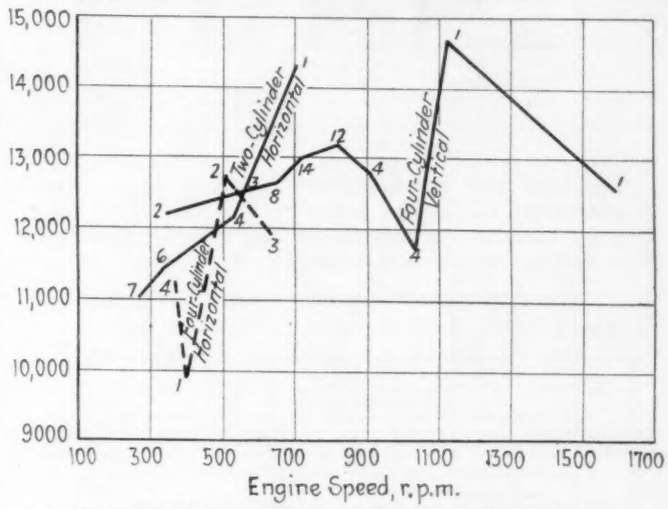


FIG. 18—PISTON DISPLACEMENT OF DIFFERENT TYPES OF ENGINE AS RELATED TO THE ENGINE SPEED

amination of the original data, however, it is found that the highest as well as the lowest figures for piston displacement are found in this class, the former being 16,740 cu. in. and the latter 9150 cu. in. The favorable showing in Fig. 18 is therefore due to the greater number of machines in this group, rather than to any uniformity of design or performance.

In the matter of the relation of the piston displacement to the diameter of cylinders and the engine speed, the indications are that the large-diameter cylinders run at lower speeds but do not necessarily have a lower piston-displacement than those of small diameter. The medium-diameter cylinders, those of from 5 to 6 in., seem to run the lowest as a group in piston displacement and at speeds from 600 to 800 r.p.m. The lowest piston-displacement mentioned above was made with a piston diameter of 4 1/8 in. at 1200 r.p.m.

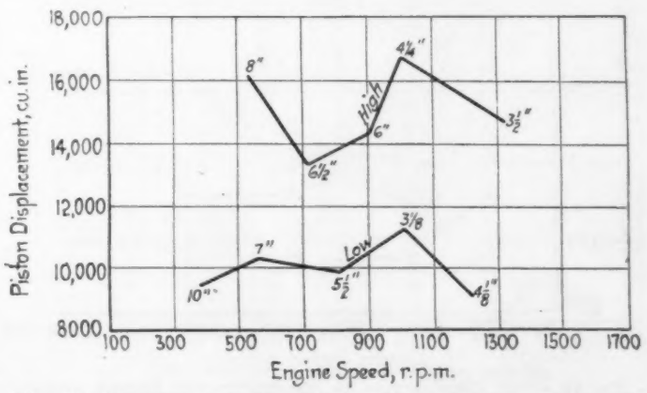


FIG. 19—RELATION BETWEEN PISTON DISPLACEMENT AND ENGINE SPEED FOR TRACTORS HAVING CYLINDERS OF DIFFERENT BORES

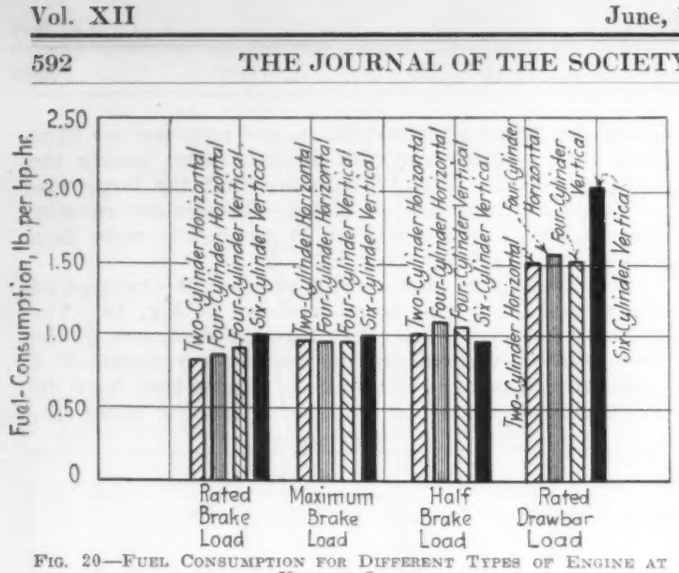


FIG. 20—FUEL CONSUMPTION FOR DIFFERENT TYPES OF ENGINE AT VARIOUS LOADS

The high and the low limits between which piston displacement varies are given in Fig. 19. They show a great variation in this factor and constitute evidence that engine design is not nearly standardized as yet.

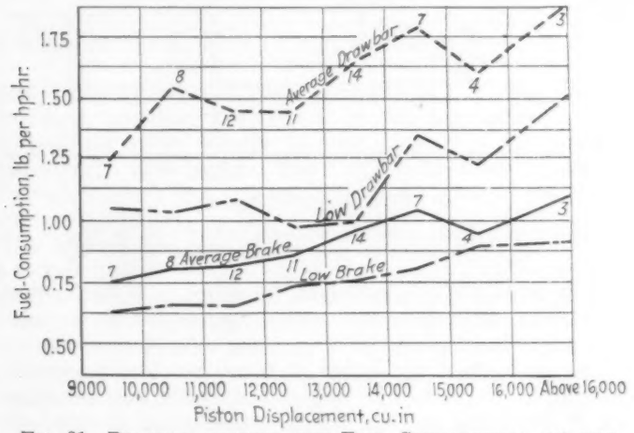


FIG. 21—RELATION BETWEEN THE FUEL CONSUMPTION AND THE PISTON DISPLACEMENT ON VARIOUS LOAD BASES

The curves indicate that the optimum speeds, as based on piston displacement, lie between 600 and 1000 r.p.m.

FUEL AND WATER CONSUMPTION

Lowering of the fuel consumption per horsepower-hour is one of the main aims of many tractor builders. That there is a great variation in the amount of fuel used per horsepower-hour is indicated by the test records. The original data disclose that the lowest fuel-consumption was 0.63 lb. per hp-hr., on the rated brake-load and 0.67 lb. on the maximum brake-load, the same tractor making both records. On the rated drawbar-test, this same tractor used 1.04 lb. per drawbar hp-hr. On this test it was equaled by one and excelled by two other tractors. The two low machines used 0.98 and 0.99 lb. per drawbar hp-hr., respectively. The highest fuel-consumption on the rated brake-test was 1.40 lb. per b. hp-hr. and, on the drawbar, the highest consumption was 2.76 lb. per drawbar hp-hr. It is thus seen that there is a great variation in the amount of fuel required per horsepower-hour for the various tractors, a variation of 138 per cent from lowest to highest on the belt test, and 181 per cent from lowest to highest on the drawbar.

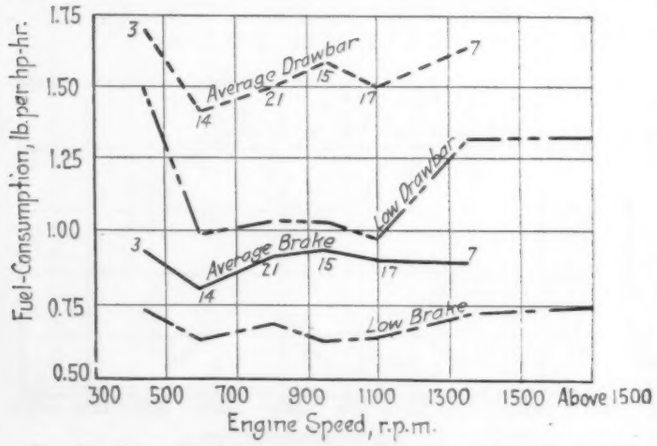


FIG. 22—FUEL CONSUMPTION AS RELATED TO THE ENGINE SPEED BASED ON THE RATED LOADS

Fig. 20 shows the fuel consumption for different types of engine on the various loads, and that no particular type of engine has the advantage throughout all the tests. All are fairly close together on the maximum belt-test, which is the most significant test so far as figures relating to performance are concerned. As would be expected, the fuel consumption tends to increase with an increase in the piston displacement. In Fig. 21, we have an average fuel-consumption for each group of tractors based on the piston displacement. Inasmuch as the tendency is to decrease the fuel consumption, only the average and the low curves are given.

The data showing the relation of the fuel consumption to the engine speed give peculiar results as shown in Fig. 22. Here it is seen that the lowest records are obtained at speeds between 600 and 1100 r.p.m. The data reveal that the lowest fuel-consumption is secured with engines having a diameter of cylinder of between 5 and 6 in.

Referring to Fig. 23, the relation of the tractor weight to the fuel consumption is somewhat surprising, especially in the horizontal-cylinder engine, in that it tends downward as the weight increases. This holds true until an approximate weight of 7000 lb. is reached, after which the curve assumes an upward tendency. In the case of vertical-cylinder engines, there is a slight upward tendency in the curve until the above weight is reached and then the curve drops very markedly. However, the number of tractors used beyond that point is small as compared to those used at the other weights, which fact may materially influence the results.

Fig. 24 indicates that the I-type engine will give better fuel-economy than the L-head engine on all operating loads. This same advantage is noted in Fig. 25, where only four-cylinder vertical engines are considered. Some interesting comparisons of the fuel consumption at various loads are given in Fig. 26. The rated brake-load gives a better economy than either the maximum or half loads. The relation is also brought out that the fuel requirement on drawbar work is almost double that required on belt work per horsepower-hour.

The water consumption per hour for the different tractors showed a wide variation, running from no water used during the 2-hr. rated-horsepower test with the air temperature at 84 deg. fahr. to 40 gal. for the same test with the air temperature at 88.5 deg. fahr. On the drawbar test, the amount of water required varied from no water used with air temperature at 87 deg. fahr. to 17.8 gal. per hr. at the same air-temperature. This wide difference in the amount of water used indicates that in some cases the cooling system has not been given the attention that it really deserves.

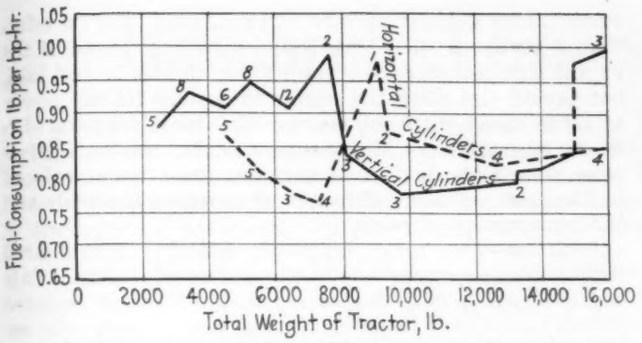


FIG. 23—RELATION OF THE TOTAL WEIGHT TO THE FUEL CONSUMPTION FOR DIFFERENT TYPES OF TRACTOR ENGINE

DEFECTS OF TRACTORS

This discussion of the defects that have shown-up in our tests is intended to be critical only in a constructive sense; the defects are mentioned in the hope that a closer study of the requirements will be made and more

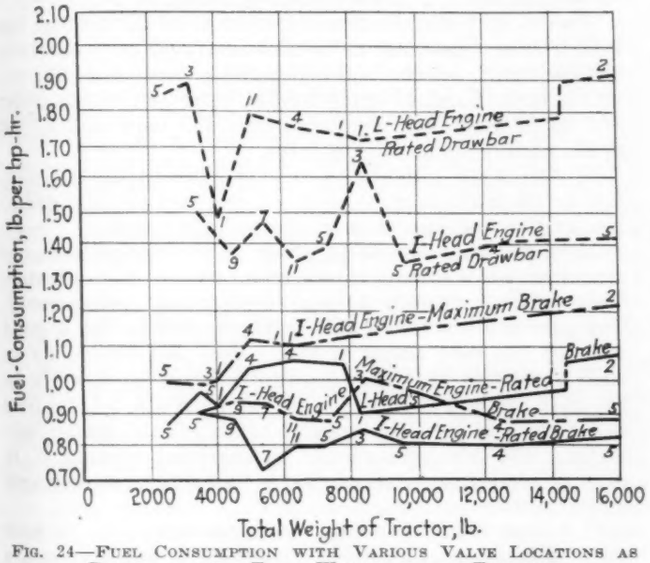


FIG. 24—FUEL CONSUMPTION WITH VARIOUS VALVE LOCATIONS AS RELATED TO THE TOTAL WEIGHT OF THE TRACTORS

rigid inspection required of all parts that go to make up the tractor, so that the final result will be a more highly improved product.

The minimum time on test for any tractor was 30 hr. of operation; and the maximum, 78 hr. All the defects mentioned have shown-up within these time limits and indicate that the tractor user must be not only an operator but a mechanic from the very first. The defects have been divided into three main groups, those dealing with the engine, the accessories and the chassis; the figures refer to the number of tractors in each case.

ENGINES

In regard to the engine and in addition to several minor defects, we note from our records the following main items:

Defective Cylinder-Blocks Replaced	3
Cylinder-Heads Replaced	1
Gaskets Burned-Out	3
Cylinders Scored	2
The main defects of the valves were as follows:	
Valves Replaced	2
Stems Ground	2
Valves Ground	4
Springs Broken	1
Push-Rods Adjusted	13

Some of the push-rods had to be adjusted several times. The necessity of adjusting push-rods should not of course be classed as a defect in the regular sense, as such adjustment is an ordinary proceeding; but the number of cases of this during the time of the testing is striking. In many of these cases the power output was increased materially. Frequently the indications were that the valves had not been fitted properly at the factory. Timing of the valves was changed in two cases.

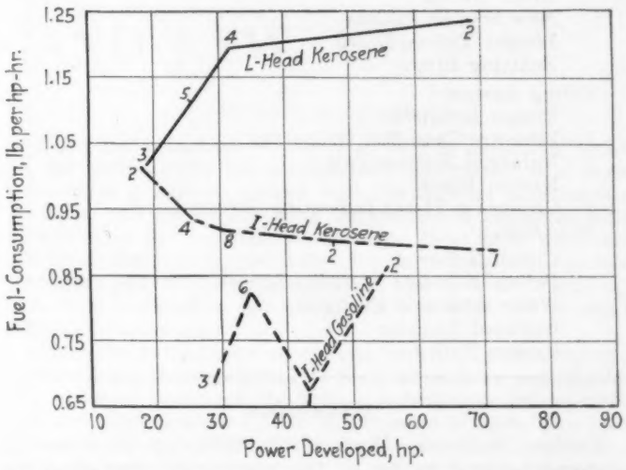


FIG. 25—RELATION BETWEEN THE FUEL CONSUMPTION AND THE MAXIMUM HORSEPOWER OF THE TRACTORS CLASSIFIED ON THE BASIS OF VALVE LOCATION AND KIND OF FUEL

Belt pulleys of the attachment type gave the most trouble, probably due to the short shaft and the fact that only one bearing was used. Lack of proper clearance between the pulley and the drive-wheel was encountered. This is especially undesirable when the tractor is used on wet ground; the soil fills-in on the drive-wheel to such a thickness that it rubs on the belt pulley and stalls the engine. The cranking of the engine while in the belt can readily be facilitated in some cases.

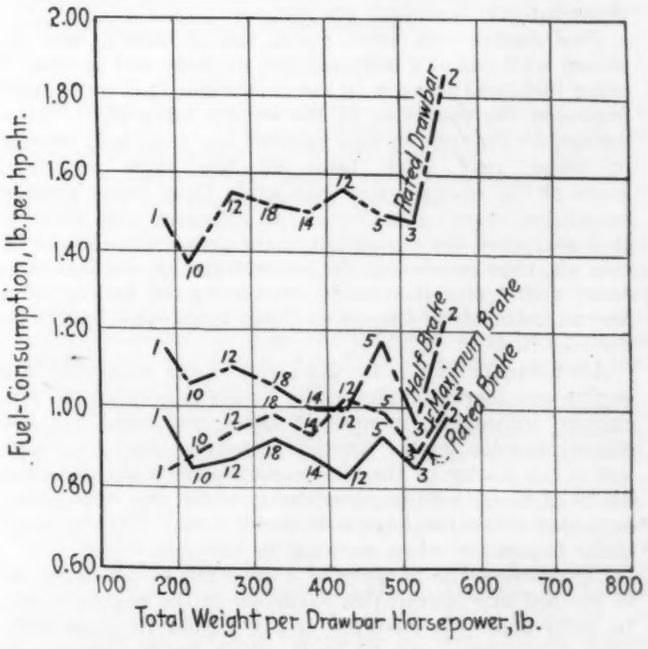


FIG. 26—THE FUEL CONSUMPTION AT DIFFERENT LOADS AS RELATED TO THE WEIGHT PER MAXIMUM DRAWBAR HORSEPOWER

CHANGES MADE IN ENGINES SUBMITTED FOR TEST

Crankshaft	
Bearings Refitted	1
Bearings Tightened	1
Connecting-Rods	
Bearings Adjusted	2
Bearings Burned-Out	1
New Grease-Cups	2
New Grease-Cup Caps	2
Pistons	Sets
Rings Butted	3
New Sets of Pistons	3
Pistons Turned-Down	2
Refitting Rings	1
Oiling System	
Pumps Repaired	2
Pressure Gage Not Indicating	1
Enlarged Suction-Pipe	1
Broken Pipes	3
Crankcase Floats Indicating Wrong Level	2
Belt Pulley	
Clutch Removed	1
Drive-Chain and Sprocket Broken	1
Whole Assembly Replaced	1
Replaced Lagging	1
Broken Pulley	1

Accessories

Cooling Systems—Most of the difficulty with cooling systems seemed to be in the matter of fans and fan drives. In 21 cases the fan-belt was the chief offender, requiring frequent tightening, replacing or relacing. In two cases the fans were replaced with larger ones. The same thing was true in the case of the radiators. Other difficulties related to the fan bearings, the pump packing, the water lines, and the valves. In some cases the cylinder-heads became very hot, even though the cooling water did not exceed a temperature of 200 deg. fahr. This may have indicated restricted circulation or that the water space was too small in the cylinder-head.

Clutch—Adjustment of clutches was necessary in 20 cases. Other difficulties were: clutch stuck, broken shoe, broken link, completely wrecked, collar bolts broken, throwout-arm loose and pin lost.

Fuel System—In seven cases, the carbureter was replaced with one of a different size or make and in several other instances changes in the carbureter that were made improved the operation of the engine materially. Altogether, 50 changes on fuel systems are recorded; several of these may have been on the same machine. Some of the changes and jobs aside from those already mentioned were: installation of bypasses and shrouds that permitted the regulation of the proportions of hot or cold air, thus regulating the temperature of the fuel mixture; nozzle size increased; air valve; the adding of a fine adjustment to the water-feed; leaks, and breaks in the fuel lines.

Air-Cleaners—In some cases the power output of the engine was increased materially by disconnecting the air-cleaner, indicating, in most of these instances, that the cleaner was too small. Another important factor brought out in the matter of the air-cleaners using water was the desirability of having them designed so that water can be added while the engine is under load. This is especially important when working in the belt.

Governors—The purpose of a governor on an engine is to prevent any appreciable variation in the engine speed. In many cases the governor is a governor in name only. That a governor can be built which really governs is shown by the many cases where close regulation is secured under a great variety of conditions. To be effective, a governor should not only control the speed of the engine throughout a load range from no load to full load, but should also allow the engine to develop its full power at rated speed when necessary. The most frequent difficulty encountered with governors, aside from ineffectiveness, was in the matter of springs; these were replaced in five cases. Other difficulties were wrong assembly and the replacement of parts.

Ignition—The most frequent difficulty encountered with ignition systems was in the matter of timing. This was changed in nine instances; magnetos were replaced in two instances. Other difficulties were: spark-coils replaced, the replacement of the breaker-points, the adjustment of breaker-points, loose couplings and impulse starters.

Chassis

Difficulties with the chassis were relatively few, and can be classed as (*a*) lack of proper lubrication; (*b*) poor steering-gears; and (*c*) weak construction evidenced by broken bolts, twisted frames and broken gears.

The weight distribution or method of attaching the load is sometimes such as to take nearly all of the weight off the front wheels, making guiding very difficult; or, on the other hand, so much weight is thrown on the front end as to make the steering apparatus very difficult to work, unduly tiring the operator.

Of the large number of tractors submitted for test, two entire tractors were replaced, one because of a defective engine and one because of a twisted frame.

More attention should be given, in the design and construction of tractors, to the comfort of the operator. This refers especially to seat design and arrangement. The operator should be able to sit so that he has a good view of the field ahead of him. The seat should be in such a position that the operator will not be directly in the path of the hot air from the fan blast nor be required to sit close to exhaust pipes or other highly heated material. The machine should be designed so that it is readily accessible in all parts for inspection, adjustment and repair.

If I were asked to make recommendations as to how these defects can largely be remedied, I would consider the following in the order of their importance:

(1) More rigid tryouts in the field under various conditions, by men other than the designer, before the tractor is finally approved for production
(2) A choice of accessories based on a thorough study of them as related to the particular machine in question
(3) More rigid inspections of parts, as well as of the finished machine

When I asked our engineer what he considered a great fault of the tractors he said: "They make a good tractor and then spoil it by using unsuitable accessories."

Results of the Tests

The following is a brief statistical record of the results secured during the three seasons the tests mentioned have been conducted:

Requests for Tests	141
Appeared for Test	89
Made Test without Changes in Tractor	51
Made Test with Changes in Tractor	35
Withdrew from Test	3
Changes Made	
Did Not Make Original Rating	12
Changed the Number of Revolutions per Minute	6
Changed Equipment	17

(*Concluded on p.* 609)

Research Topics and Suggestions

THE Research Department plans to present under this heading each month a topic that is pertinent to the general field of automotive research, and is either of special interest to some group of the Society membership or related to some particularly urgent problem of the industry. Since the object of the department is to act as a clearing-house for research information, we shall be pleased to receive the comments of members regarding the topics so presented, and their suggestions as to what might be of interest in this connection.

TIRES—OLD AND NEW

WHEN a new development changes some basic condition on which an industry or a product has been developed, the new possibilities in the way of further development made possible by the new conditions are often very slowly realized. When a given process has been carried on in a fixed way for a long time it is not easy to remember all the reasons why the process is as it is and how new conditions can permit of improvements or what changes they demand.

One of the most rigidly fixed conditions that have determined the progress of design in passenger vehicles is the standard pneumatic tire. Without the Otto-cycle engine and the pneumatic tire or their equivalent, as yet undiscovered, the automotive industry in its present form would not exist. The only other single element that remotely approaches either in importance is the electric starting-system. While tires have developed in reliability and general performance perhaps as much as have engines in the past 20 years, there has been no marked change in the action of the tire as a mechanical cushion for the vehicle. If a set of the tires and wheels of 20 years ago could be placed on almost any car of present-day design the average person probably would not notice the differences in the mechanical behavior of the vehicle.

Whatever are the reasons why tires have been made for 20 years with about the same tire diameter for a given load, about the same wheel-base diameter, about the same inflation-pressure and even roughly the same flexibility of the carcass, the fact that this has been the custom necessarily has been one of great importance in determining the design of many elements in chassis and body assemblies. In fact, hardly any important part of the vehicle has been unaffected by the mechanical conditions imposed by the degree of vibration that the tires permit to reach the other parts of the vehicle.

The prospect that the industry may introduce, or be introduced to, a type of tire differing radically in most of its mechanical characteristics from the present type opens a very interesting field of speculation as to what may be expected in the future. Some of the features of design that are most directly dependent on tire characteristics can be predicted, however, without much speculation. The possibility or probability that the general adoption of some form of tire giving a degree of cushioning that is distinctly more effective than that of the present type will make possible important modifications of design in the direction of lower cost and longer service, as well as greater comfort, invites a careful study of the different possibilities by automotive engineers. We shall attempt here merely to suggest a few of the more obvious features in which such a new type of tire may open up possibilities for advances in car design.

The outstanding feature of any prospective tire development is a reduction in the average and the maximum accelerations, not only vertical but perhaps also longitudinal and transverse, that can be imparted to the chassis by the reactions of the road. The reduction of impact should be more marked for the small irregularities of road surface than for the large ones, that is, for block pavements than for road "corrugations." This seems obvious without further comment. The following suggestions are based on a comparison between the standard and the prospective type of tire in this respect.

Axles and Wheels

Since the reduction of the ratio of the unsprung weight to the total weight has always been recognized as a desideratum, it is safe to assume that the weights and the sizes of front and rear axles have approached a minimum practicable limit for economic production. Even more than most parts of the vehicle, the axle sizes have been the result of practical experience rather than of theory and computation and this experience has been obtained with the standard types of pneumatic tire.

Since the more severe stresses to which an axle housing or a front axle is subjected arise from impacts or accelerations imparted to it through the tires, a reduction in the maximum stresses thus produced or in the number of times the stress exceeds the safe limit for repeated stress will necessitate less strength and less weight in the axles. We would predict, therefore, that for a given degree of reliability the axles for use with more flexible tires could be made lighter, but how much lighter probably only either experience or a systematic research on axle accelerations can determine. For this reason, and also because the transverse shocks are cushioned to a greater extent, the strength of the wheels can probably be reduced. But as the change in the tire size requires a different rim-size and perhaps involves a different tire-weight, one can hardly predict anything about wheel weights.

It is not clear just what factors have determined the present practice as regards wheel diameters, but probably body height, road clearance and other considerations have had as much to do with this as tire characteristics; hence it may be doubted whether modifications in the tires alone will cause any radical changes in wheel diameter.

Springs

Much has been written on the subject of springs, mainly from the point of view of cushioning the frame against the vertical displacements due to road irregularities. Not much attention seems to have been given to the question of cushioning the fore-and-aft or the transverse shocks, nor to the elimination of the minor vibrations that are due to resonance effects in the springs themselves. Effects of the latter sort are undoubtedly of much more importance as regards the comfort of the passengers and the vibration effects on the vehicle than has been generally recognized. They are perhaps responsible for most of the minor vibrations that are chargeable to the road, yet we know of nothing in print that deals directly with this subject.

Whatever is the nature of the spring reactions that are responsible for these effects, they are influenced mainly by the impacts of the wheels on the road as evidenced by the marked effect of tire inflation. It is to be supposed, therefore, that the reduction or the practical elimination of these secondary spring-actions would be the main result of the substitution of softer tires.

It is evident that there are two qualities of springs that might be subject to change to better adapt them to the new tires. These are the damping and the initial deflection. In fact, these are the only differences between them as regards their simple vertical reactions. Torsional rigidity, method of shackling and the like, of course affect the rolling and the

pitching periods and the horizontal rigidity of the suspension.

For practical reasons of clearance and capacity for variable load, the initial deflection is perhaps limited to about the present practice, except for some radical departure such as adjustable spring-tensions. However, the optimum amount of friction or damping effect of the springs or of shock absorbers that supplement this effect may be dependent on the tires. The use of tires that give to the axle upward accelerations on impact with the ground, which are comparable with the downward accelerations produced by the springs and not many times greater than the downward accelerations, may require an entirely different amount of damping of the spring action.

Frame Stiffness and Body Structure

The extent to which the dimensions of the frame members are fixed by the excess loads placed upon them by spring reactions is probably not well known. If these reactions are an important factor in fixing the stiffness of the frames, however, important changes in the frame dimensions and design might ultimately result from the adoption of the new style of tire.

The immense amount of effort that has been put into the design of bodies, particularly closed bodies, to keep them quiet and intact under the punishment of vibration, suggests that the body designers might find some of their worst troubles lessened or lost if the tires would take over a much larger share of the problem of cushioning road-shocks.

Weight in General

If it should come about that the unsprung weight can be reduced by virtue of a softer tire-action, and particularly if the stiffness of the frame and the body work can be reduced for the same reason, there appears to be a possibility of much reduced car-weights, together with greater comfort of the passengers. We are fully aware that the foregoing random discussion contains no definite facts whatever. Its object is not to present facts but to suggest that the progress of passenger-car development during the next few years, particularly if a new and softer style of tire is generally adopted, can perhaps be greatly hastened by a systematic investigation of the several features of design, some of which are suggested above, that may be radically influenced by changes in the mechanical behavior of the tire equipment.

SPREAD IN PRODUCERS' AND CONSUMERS' PRICES

THE public, in this country at least, has grown to expect such a variety of goods and services that more people are engaged in the secondary processes than are engaged in primary production. To be exact, of 41,614,248 people engaged in gainful occupations in this country, 29,570,867, or about 71 per cent, are engaged in manufacturing, transportation, distribution and allied activities. In view of these figures, why regard it as extraordinary that the primary producer gets less than one-half? The fact is that we are accustomed to a narrow meaning of the term "production." The act of transportation from one section of the country to another, or of delivering from the grocery store to the kitchen, is part of the process of producing the commodities *where* they are wanted, and every act of grading or preparing them for market is part of the process of producing them *as* they are wanted by consumers who are located at more or less distant points.

There is a common theory that a great number of superfluous people have interposed themselves between the producers and the consumers, but common observation should teach that the buyers are always studying how to get to the original sources and procure their supplies as cheaply as possible. The idea that goods may be handled over and over indefinitely, with each holder exacting a profit without rendering any service, is too simple to be believed by anybody who has had much business experience.

The Joint Congressional Commission of Agricultural Inquiry finds that the development of more expensive methods and service in distribution is in obedience to the wants of the public, and that it is useless to decry such methods if the public insists upon having them. The Commission suggests that one obvious point where a start can be made is the elimination of countless thousands of varieties, kinds, styles and sizes. The stocks of goods offered consumers have become multiplied beyond all reason, necessitating the carrying of much larger stocks than are necessary on the part of dealers, thus tying up much material and credit, all of which has ultimately to be borne by the consumer. Nevertheless, a dealer who has the variety makes an appeal that is persuasive with the average buyer.

The growth of cities is another factor in higher costs to their inhabitants. The congestion of traffic and the physical difficulties that attach to city delivery are increased as population grows.

The Commission attributes much of the spread to the poor market facilities for perishables that exist in many American cities. The report states that it is the belief of the Commission that the lack of properly established joint terminal markets is responsible for many of the extravagant costs in the distribution of agricultural products and that steps should be taken by municipalities, transportation companies and marketing agencies to create facilities for the efficient handling and the conservation of foodstuffs.—National City Bank.

AUTOMOTIVE VEHICLE INSURANCE

THERE are 20,000 motorbuses in operation; 600 cities have organized motorbus lines. There are 60,000 garages in the country; 55,000 repair-shops; 50,000 passenger-car and motor-truck dealers. Six billion people are carried annually by motor cars, and over 1,000,000,000 tons hauled annually by truck.

In rating cars from the insurance standpoint they are divided roughly into

(1) Private passenger
(2) Commercial
(3) Public, those used for transportation of passengers for a consideration
(4) Garages
(5) Automobile dealers
(6) Manufacturers

A private passenger-automobile is any gasoline or steam car of the private-passenger type used for pleasure or business purposes. A commercial automobile is any machine of the truck or delivery type. This includes a number of odd classes such as ambulances, fire-department automobiles, industrial trucks and tractors. Public automobiles include any machine used for carrying passengers for a consideration.

The average liability claim today costs about $300, exclusive of loading expenses. The average property-damage claim is about $35 or $40. The average collision loss is about $75. Large personal-injury verdicts are common and warrant selling limits on policies that are larger than $5,000 and $10,000.

Automobile risks having 10 or more machines under one ownership and operating management can have a special rate that is known as an experience rate made, provided the owner has been insured for 2 or more years and provided a premium has been received on at least 10 machines for 21 consecutive months.—O. M. Doyle, Standard Accident Insurance Co.

Vol. XII June, 1923 No. 6

The General-Purpose Farm Tractor

By C. M. Eason[1]

Chicago Tractor Meeting Paper *Illustrated with* Photographs and Drawings

THE author divides the history of the application of mechanical power to farm work into three periods, reviews each one and comments upon the various phases of progressive development that influence the type of tractor most desirable for satisfying present needs. The requirements of farm work are outlined, and the different types of tractor built and being constructed to meet these demands are reviewed, discussion of large versus small tractors, type of drive, power needed, control, methods of operation and the factors constituting general-purpose service being included.

So far as adopting the tractor for farm usage is concerned, the author believes that the present limitation of such utilization lies with the tractor industry and with tractor engineers, rather than with the farmer.

THE history of the application of mechanical power to farm work can be divided into three major periods. The first, from about 1880 to 1910, covers the practical use of the steam engine for the operation of both grain separators and heavy plowing. The second period, from about 1900 to 1915, covers the development and evolution of the heavier type of gasoline or kerosene engine used essentially the same as the steam traction-engine. The third period begins about 1913, and the first phase of this ended in September, 1920. We are still in this particular period, which can be designated as that covering the light gasoline-driven tractor.

The first record that we have of a tractor or road engine is covered by a United States patent issued in February, 1817. This was nearly 10 years before Stevenson ran the first locomotive and railroad train in England, and more than 10 years before the DeWitt Clinton ran first in this Country. Many other patents between 1817 and 1863 covered various schemes for road engines, steam coaches and the like, none of which amounted to anything commercially. The earliest record of a steam tractor having plows attached to it is in a patent issued in 1856. It was not, however, until the Country had begun to recover from the effects of the Civil War, that is, in the 1870s, that any practical application of steam power was made to farming operations.

This first application consisted of utilizing a portable steam engine, such as was being used at that time for operating small sawmills. The engine was belted to a grain separator or threshing machine which, at that time, was being operated principally with horse tread-mills or horse sweep-powers. J. B. Bartholomew, of the Avery Co., says that these portable threshing-machine engines were fairly common in central Illinois in 1879, and that a considerable demand developed among the users for a machine that would be self-propelling. The following year, 1880, several of these self-propelled tractors were brought out. The first ones consisted of a suitable gearing for the rear wheels, and a belt drive from the engine flywheel to the countershaft of this gearing. A tongue was connected in front, and a team of horses was used to guide the rig. That year marked the use of the first

Fig. 1—The Original Wysong & Eason Tractor Pulling Six 14-In. Plows in Buffalo Grass Sod

100 self-propelled steam-engines in the United States, and is therefore taken as the beginning of the steam-engine era of power farming.

The invention and perfecting of a steering-gear, a patent for which was issued in 1880, and later the introduction of a clutch and gear train between the engine and the driving wheels together with a number of detail patents relating to compensating gears, mountings and the like, marked the early stages in the evolution of the steam traction-engine. The main idea of these early designers was to develop a threshing engine that would be able to propel itself and pull a separator along with it from one farm to another. The manufacturers, however, had not much more than perfected the steam engine so that it would do this satisfactorily when the owners in several parts of the Country began hooking plows on behind the engine and attempting to do plowing when they were not engaged in threshing. Some of these earlier attempts merely made use of the horse-drawn walking-plow, and required one man for each plow in addition to two men to run the engine. From this beginning it was only a step to hooking up horse-drawn sulky-plows behind the

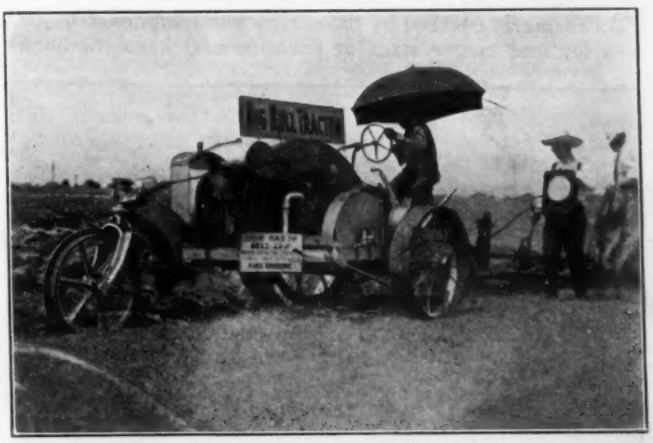


Fig. 2—The Bull Tractor at the 1916 National Tractor Demonstration

[1] M.S.A.E.—Vice-president, Samson Tractor Co., Janesville, Wis.

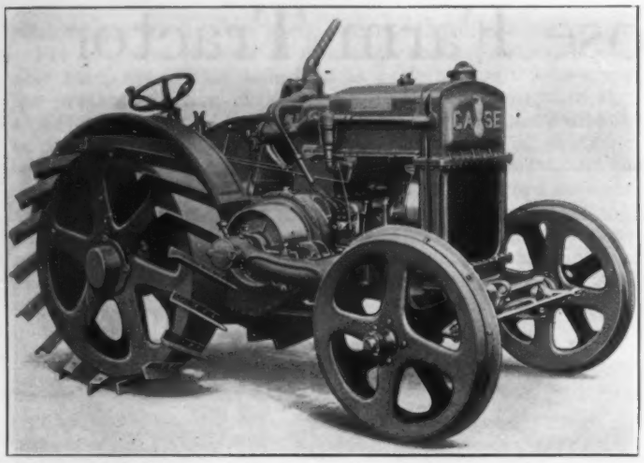


FIG. 3—THE CASE TRACTOR RATED AT 12 TO 20 HP.

steam engine and, about 1898, the first special engine-drawn gang-plows were built.

About 1890 to 1892, it was a marvel to see a steam engine plow; and it was then that I saw the first steam plowing-rig in southwest Kansas; but, by 1902, there were 30 steam plowing outfits in Meade County, Kan. Many of these were the largest, heaviest compound steam tractors ever built, and most of them pulled plows made up of an especially heavy three-bottom unit, hitched behind a long beam that was attached to the engine by log chains and steel cables. Two men for the engine itself and usually two or three plow-tenders were required to keep one of these outfits going. Besides this, it required a man and team to haul coal and one or two teams with tank wagons to haul water. I know this definitely because I once had a job on a tank wagon trying to haul water enough to a Reeves compound 32-hp. engine that was pulling 12 plow-bottoms. It also required the services of another man, team and plow to keep the corners plowed out. These big steam rigs worked very well and showed a profit on their large-scale operation so long as they had virgin sod to work on; but, after the ground had been turned up and in wheat for two seasons, they were not so satisfactory for the second plowing, although the use of steam tractors continued for several years after the time of which I speak, and they are in use in some sections even at present.

The production of steam traction-engines reached its maximum about 1910, and has since declined because the field formerly covered by these rigs was taken over by the heavier and larger sizes of gasoline and kerosene-burning tractors. From a maximum production of 14,000 in 1910, steam traction-engine production has dropped until there are probably not more than 500 to 600 made each year at present.

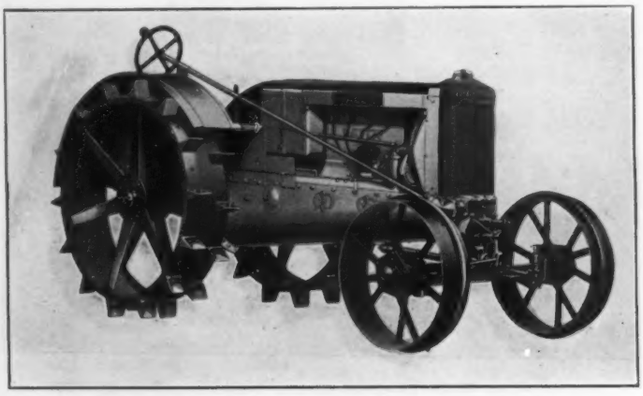


FIG. 4—THE 1923 MODEL WALLIS TRACTOR

INTERNAL-COMBUSTION-ENGINE APPLICATION

The limitations of the steam tractor for plowing work became apparent almost as soon as it was started, and many inventors turned their minds toward adapting the internal-combustion-engine to this class of service. Some machines of this type, making use of a steam-tractor running-gear and a stationary type of gasoline or kerosene engine, were built in 1900. It was not until about 1907 that the first 100 successful gasoline-driven tractors were actually in use in this Country. From 1908 to 1915 the development of the heavy gasoline tractor was extremely rapid, and some spectacular successes and failures are on record covering this period. The first national tractor demonstration held in the United States was at Fremont, Neb., in 1912. At this demonstration the gasoline-driven tractor predominated. There were a few steamers on exhibition, but it was plainly to be seen that the chief interests centered on the gasoline and the kerosene-engine job. By 1913, however, the large-tractor boom had reached its maximum proportion, and 1914 marked the beginning of the end of this era of development. It also marked the beginning of the third era that of the small gasoline-driven tractor.

LIGHT TRACTOR

The ideas underlying these different eras had their inception long before the machines were accepted by the public and, in the same way, the light-tractor idea had been working for many years before it actually was commercialized. In 1903, after my experience in hauling water and swabbing flues for the steam-tractor rigs, I concluded that what we wanted was not a big clumsy outfit for custom threshing and plowing, but a little, light, cheap, versatile tractor that every farmer could own individually and do what he pleased with. Ansel S. Wysong was the chief instigator in developing these schemes. We came to the conclusion more or less jointly that the tractor was our one certain road to fame and fortune. We had not only worked on the steam outfit, but were assiduous readers of technical periodicals and persistent gatherers of catalogs and printed information put out by the early motor-car builders. We therefore felt qualified to design a farm tractor.

We decided that we wanted a machine weighing not more than 2 tons, that would pull three 14-in. plow-bottoms and that could be sold profitably for $750. Our first effort embodied the brilliant idea of dispensing with one rear wheel, and the consequent cost and complication of a differential gearing. We worked out a simple spur-gear and chain drive to connect-up our one drive-wheel with a two-cylinder two-cycle vertical-engine, purchased from the Cushman Engine Co., at Lincoln, Neb. Our first tests with this machine occurred in October, 1904, in a potato field near Topeka, Kan. We were out in the field for 2 days, and then decided that one drive-wheel was not sufficient; consequently, we made the job over. Using the same engine, we built an additional rear wheel, got a differential and some more chain and provided a single steering-wheel in front, mounted on a turnable arrangement. We finished the job that winter and, by the spring of 1905, had it down in our southwest Kansas home for a practical tryout on a farm. We had determined previously, by using a home-made dynamometer, that only 300 to 400 lb. drawbar pull was needed for one

14-in. plow at the depths ordinarily plowed in southwest Kansas; that is 3 or 4 in. We figured it was mere boys' work to determine that a 15-hp. engine was much more powerful than would be needed to propel a 4000-lb. tractor and draw three 14-in. plows behind it. However, when we got this machine out in the field, the best we could do was draw two plows, and those not any too well. We did, however, plow about 40 acres that spring and double-disced 120 acres, seeding it to barley in a third operation. At harvest time we purchased a 6-ft. binder and, by using two operators, cut the entire 120 acres of barley with a reasonable degree of satisfaction; but only

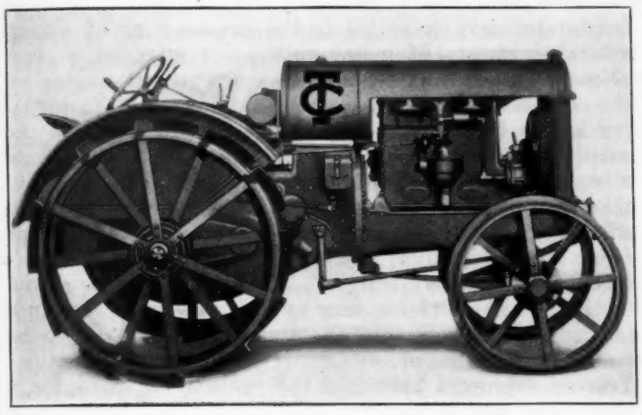


FIG. 5—THE TWIN CITY 12-20 HP. TRACTOR

by much night work to keep the machine in running order. We later put on a two-cylinder apposed four cycle engine, made by the Brennen Engines Co. This had about 20 hp. and pulled three plows very satisfactorily. At one time just for a stunt we pulled six 14-in. plows with this rig, as shown in Fig. 1.

When we tried to organize a company for the construction of the tractor, we found that we could not interest

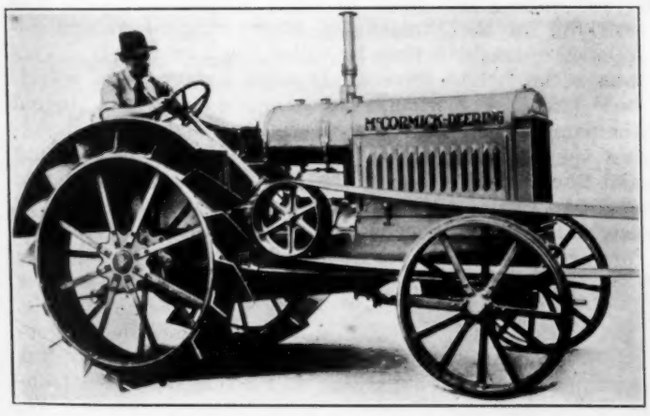


FIG. 6—THE MCCORMICK-DEERING 15-30 HP. TRACTOR

anyone in our project unless we agreed to make a "real" tractor that would pull 10 or 12 plows; consequently, we agreed to make one. But we failed after two years of heartbreaking work, simply because we did not have technical knowledge enough to carry our designs through to a final conclusion.

The first machine to be put on the market in any significant quantities was the Bull tractor, which was started in a small way about 1912, but was really not heard of

[2] See TRANSACTIONS, vol. 11, part 2, p. 363.

FIG. 7—THE AVERY 15-30 HP. TRACTOR

until it took the Country by storm in 1915. Several thousand of these tractors were built in the original model, illustrated in Fig. 2.

The commercial success of the Bull tractor had a tremendous influence on the tractor industry and, by 1916, there were 165 different companies in this Country attempting to duplicate its success with the small tractor. In my paper on the Farm Tractor,[2] presented before the

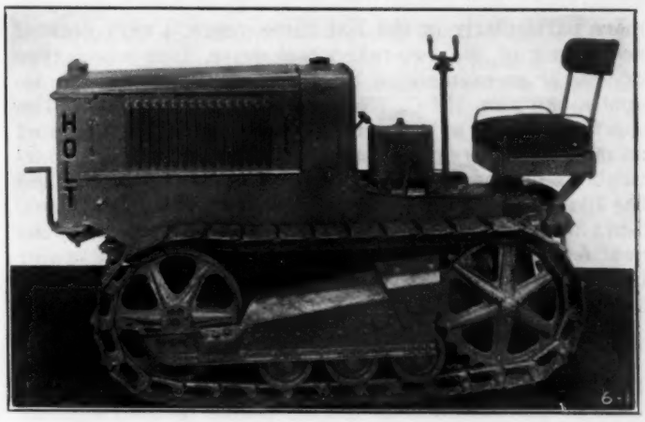


FIG. 8—THE HOLT T-35 TRACTOR

Society in 1916, I gave a résumé of the tractors then on the market. It is interesting to note that, of the 32 machines that I selected to illustrate this presentation, only three are on the market today, unchanged from their original form, except for detail refinement and improvement. These are the Rumely, the Avery and the Aultman-Taylor, all of the large type laid down originally to take the place of the steam threshing-engine. Four or five others of the machines presented at that time are very nearly the same now as then; these are the Lauson, Waterloo Boy, Avery 8-16, Gray wide-drum drive, and Holt 45 caterpillar. Changes from the originals of these models are sufficient to call them new machines, but they

FIG. 9—THE AVERY TRACK RUNNER TRACTOR

FIG. 10—CULTIVATING CORN WITH A POWER CULTIVATOR HAVING A TRIANGULAR ARRANGEMENT OF THE WHEELS

are practically the same design as formerly. All of the other machines shown 7 years ago are extinct.

In the place of the heterogeneous constructions of 1916, there has arisen during the past few years, and more particularly in the last three years, a very decided acceptance of the two-rear-wheel drive, four-wheel type of tractor as exemplified by the Fordson, Wallis, Minneapolis, the new I.H.C. 15-30 and the Avery 15-30. The caterpillar type of tractor has also come to be accepted as meeting the requirements for a special machine, particularly on commercial work such as road building and the like. The modern line of Holt machines, the 10-ton, 5-ton and T-35 models, brought out since the war the new Avery Track Runner and the latest Bates Crawler Drive are representative of this type of machine. Figs. 3 to 9 inclusive show this evolution.

POWER CULTIVATORS

It is rather difficult to say whether the general acceptance of the conventional tractor is due to the fact that this is inherently the best type of tractor for farm use, or whether the spectacular commercial success of the Fordson tractor has not served to crystallize the type more than any other one factor. Whatever the reason, the light tractor that shows clearly the effects of automotive engineering does predominate, and has been accepted as standard and conventional by the farming public. Everyone, however, with the possible exception of Mr. Ford, is ready to admit that the conventional type of tractor has its limitations and that all the farm work on all the farms all over the United States cannot by any means be accomplished by the four-wheel, rear-wheel-drive type of tractor as made at present. That it performs its functions effectively and efficiently, within the limitations of its type, cannot be questioned. As a drawbar power-machine for plowing and discing, these tractors are very successful and within the limit of their engine capacity they are very satisfactory for belt work. There is a decided tendency toward individually owned small grain separators, ensilage cutters, wood saws and the like, and these lighter tractors of the two and three-plow capacity take care of this kind of machinery in good shape. On the diversified farms, where row crops as well as small grains are raised, there are actually more hours of work per year to be done in cultivating and in the numerous odd jobs now taken care of by horses, than there are hours of work at plowing, discing or belt work. This condition is summed up very neatly by the United States Department of Agriculture[3] as follows:

> The construction of most four-wheel and crawler-type tractors is such that they are not satisfactory for cultivating corn. When such a machine is bought, the number of horses that will be necessary to retain is the maximum required for the cultivation of corn and for other work coming at the same time.... If the corn is to be cultivated with horses, it will usually be necessary to retain at least one horse for each 20 acres of corn.

These facts, which are fairly well recognized by most tractor builders, have led to the development of a considerable variety of motor cultivators intended to supplement rather than replace the conventional tractor on the corn-belt farms. Everyone familiar with the industry knows the relative importance of row crops to the small grain crops of the Country, and is therefore keenly alive to the necessity of developing machines that will take care of the work that must be done effectively and efficiently. Building a power cultivator is as different from building a light tractor as a light tractor is different from a heavy tractor. The problems to be solved in the power cultivator may appear easy at first glance but, after one gets into the subject, there seem to be many limitations of an entirely unsuspected nature. Tractor engineers have had the problem in mind for a long time, but it was not until about 1917 that power cultivators, as such, were offered to the public by responsible manufacturers. Some of these earlier machines are typified by the Avery, Bailor, Emerson-Brantingham, Rock Island and Parrett cultivators. All of these were three-wheel machines; that is, they had their wheels disposed in a triangle, with one wheel between the center corn rows and set ahead of the driving wheels, which were between the outside corn rows. They all carried two-row cultivators, and were recommended for cultivating only. Fig. 10 shows this type of power cultivator.

For some years prior to 1918, William Springer was working on the problem of power cultivation and developed a machine that he called the Jim Dandy. This was a four-wheel-drive affair with a very short wheelbase and a very wide tread, relatively. It was steered the same as a Muley-type caterpillar; that is, by changing the speed of either set of wheels, by declutching and applying a brake to the side around which it was desired to turn. Mr. Springer used a belt drive on his original machine because this gave him a very simple forward and reverse control and the belts also served in the place of clutches by using a belt tightener or idler to apply tension. In the original machine built by Mr. Springer, there was no intention of carrying the development beyond a simple light cheap power-cultivator, for utilizing a two-row cultivator and a corn-planter attachment, the latter arrangement being illustrated in Fig. 11. The idea was purchased from Mr. Springer by the General Motors Corporation in 1918, and some further development work was done on the job with the idea of making it a universal or general-purpose machine. It was christened the Samson Iron Horse and some 1500 or 1600 of the machines were built according to the revised design and distributed to farmers. It was found, however, that there were certain mechanical limitations to the design and some inherent difficulties with the belt drive which, for a general-purpose machine, made the scheme undesirable; consequently, it was abandoned.

Another machine that belongs in the two-row-culti-

[3] See Department of Agriculture Bulletin No. 1296, City of Washington.

vator class is the Toro. In this machine, the driving wheels are set ahead of the cultivator shovels and pivoted, with a universal-joint drive so that they can be steered. The drive-wheels are set two rows wide, and the third point of support is behind, between the center rows. For straight going down the corn rows, the trailing wheels are locked in position and all steering is done by the leading drive-wheels. When the end is reached the trailer wheels are unlocked, are allowed to swing free and a differential brake is applied to the inside drive-wheel; whereupon, the whole rig turns around one wheel and is ready to come back in the adjacent corn row. It is claimed that there is a considerable advantage in the additional flexibility of the unit when built in this manner and, further, that there are many other operations that can be done successfully with this type of machine around the farm. In addition to handling cultivator shovels of all sorts, and there is an infinite variety of these to be taken care of, this machine is arranged to operate a middle buster or corn lister and, due to the spacing and arrangement of the wheels, it takes care of this operation very satisfactorily. A two-row corn-planter attachment has been applied to the machine and also a mowing-machine cutter-bar. With these different attachments, the Toro cultivator merges into the general-purpose type of tractor. Two views giving some idea of the versatility of this machine are reproduced in Fig. 12.

In summing up this subject of the conventional type of tractor supplemented by a motor cultivator, it would seem that the combination is thoroughly justified for corn-belt farms of more than 160 acres, and is one that will be maintained for many years to come. Table 1 submitted through the courtesy of the Avery Co., shows what can be done on a large corn-belt farm, operating on the recommended three-year rotation basis, with 120 acres of corn and 60 acres of oats for each year's crop. The time is figured on the basis of a three-plow tractor for plowing and discing, and a two-row cultivator for planting, harrowing and cultivating corn. The time required for the different operations and the date at which these operations must be carried out to be most effective in central Illinois are stated in Table 1.

Table 1 gives a total of 61 days for *one man*, spread over a period of 3 months and 10 days, and brings both the oats and corn up to the time of harvest. If this method, which is entirely possible, is contrasted with that usually employed for the same acreage, using men and horses for all of this work, it will be seen readily that there are both an advantage and a profit in doing the work with the tractor and the cultivator. To duplicate this using horses, instead of tractors, would require three or four men to accomplish the same amount of work as one man can do with the motorized equipment.

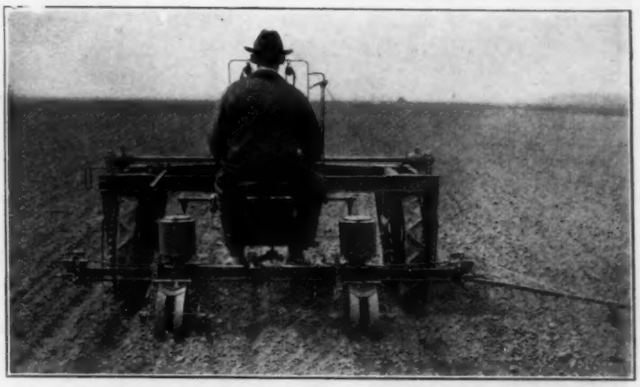


FIG. 11—A TWO-ROW CULTIVATOR AND CORN-PLANTER COMBINATION

TABLE 1—THREE-PLOW TRACTOR AND TWO-ROW CULTIVATOR WORK REQUIRED ON A 160-ACRE CENTRAL ILLINOIS FARM

Date	Kind of Operation	Time Required, Days
April 1 to 7	Double-disc 60 acres, four-row	3
April 1 to 7	Drill-in 60 acres of oats	3
April 17 to 30	Plow 120 acres for corn	12
April 24 to 30 or May 1 to 7	Double-disc and harrow the plowed ground in one operation	5
	Total time, three-plow tractor	23
May 8 to 14 or May 15 to 21	Plant corn, using motor-cultivator and corn-planter attachment	7
May 25 to 31	Harrow after planting, using motor-cultivator and peg-tooth harrow covering four rows	4
June 1 to July 10	Cultivation:	
	First	8
	Second	7
	Third	6
	Fourth	6
	Total time, motor-cultivator	38

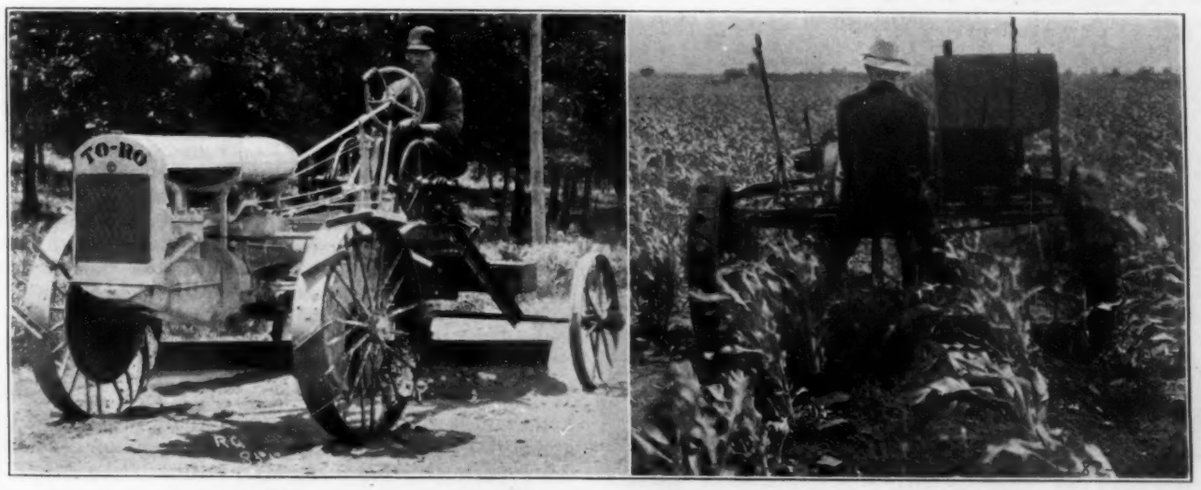


FIG. 12—TWO VIEWS SHOWING THE VERSATILITY OF ONE TYPE OF TWO-ROW CULTIVATOR

FIG. 13—A TRACTOR EQUIPPED WITH A CORN BINDER

Since the corn, hog and cattle combination has proved to be a more profitable method of farming than to specialize on grain alone, the three-plow tractor and the motor cultivator on farms large enough to support the investment is a labor-saving combination, and already has proved profitable to farmers who have been doing their work in this manner.

GENERAL-PURPOSE MACHINERY

There is some question as to whether farms of less than 160 acres can be made profitable, but the fact remains that more than one-half of all the farms in this Country are in quarter-section sizes or less. While many of these quarter-section farms could, because of favorable location and good management, support the investment in a three-plow tractor and two-row cultivator, it is doubtful if this much equipment would prove profitable throughout the Country as a whole. There is, therefore, a considerable volume of business to be had for a machine that will farm the smaller units, averaging 100 acres per farm, profitably.

Recognizing this potential market, many attempts have been made to combine in one machine the ability to both plow and cultivate and do as many other of the farm operations as may be possible, with one power-plant. A tractor designed along this line is usually called a general-purpose tractor. The machines in this class that have already been put on the market can be divided into three general classes, with some minor variations. First, the two-wheel front-drive, of which the Hoke, Moline and Allis-Chalmers are representative. Second, the crawler type, such as the Bates, Bean Spray Pump and Cleveland. Third, the four-wheel straddle type with a high center clearance, such as the LaCrosse Model M, the Parrett Cultor and the Rock Island plow tractors.

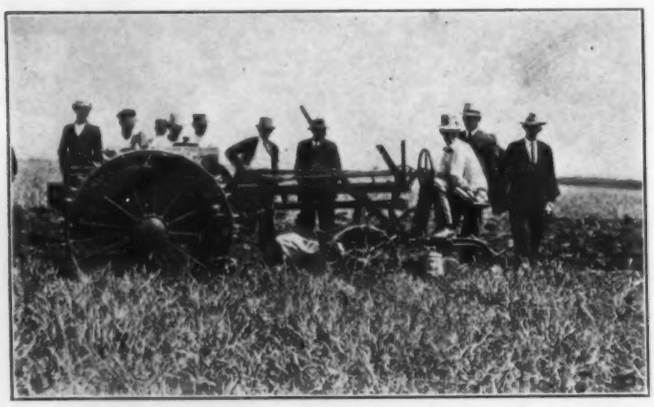


FIG. 14—THE FUNK CULTIPLOW THAT WAS EXHIBITED AT THE 1917 TRACTOR DEMONSTRATION

The Hoke tractor was one of the earliest attempts to combine in one tractor the ability to handle all farm implements pulled by two or three horses. The first of these were built privately in 1912 and 1913. This tractor is now known as the Indiana and is shown in Fig. 13 at work binding corn. The following is quoted from a letter received March 13, 1923, from the Indiana Silo & Tractor Co.

> This tractor is constructed on the theory that a tractor to be an economical proposition must more thoroughly replace horses than does the ordinary four-wheel type. It is possible with this construction to handle every crop operation on a corn-belt farm, or even on a cotton-belt farm, without the use of horses. ....We wish to call attention also to the fact that the tractor is used with the ordinary farm implement which the farmer has been using with horses, so that no extra farm equipment is necessary with this tractor, except a plow. We have customers operating 160-acre farms completely with this tractor and a single team of horses, the horses being used for whatever wagon work is necessary, but not on the crop operation. We have about 1600 of these tractors in the field.

There is some question as to whether Mr. Hoke or T. B. Funk was the first to experiment with the two-wheel front-drive type of machine. Both men, working independently, arrived at about the same conclusion. Mr. Funk's experience is rather interesting. His first tractor was built of a pair of mowing-machine wheels and the engine from his motorcycle. He provided the job with a pair of plow handles, the idea being that a man could walk along behind and guide the machine and the cultivator shovels or plow. So far as is known, this particular machine antedates all of the so-called garden-tractors, a considerable number of which are now on the market. Mr. Funk says:

> The first machine was built down at Yukon, Okla., and was made up of a motorcycle engine and some mowing machine wheels and a little bicycle chain and some sprockets. The object was to determine whether the thing would work and if not, why. No data were available relative to drawbar requirements, the horsepower needed or anything else, for that matter. The cobbled-up job seemed to "point the way," so * * * I came up to Indianapolis and laid down a paper job with a motorcycle engine but with the worm drive and a regular transmission system all enclosed. This job proved to be too light to do much work. However, it was easily steered and by that I mean comparatively easy, but it was not strong enough. When we made it more powerful and put in enough weight to utilize the power it became too heavy to steer manually. The natural thing to do then was to change the steering, and in this development it soon became apparent that the operator might as well ride as not, so we put him on the implement because there was no room for him any other place.
>
> The second machine was an air-cooled engine, the third a single water-cooled cylinder and the fourth a twin V engine. The fifth, which was the Cultiplow shown in Fig. 14, was a two-cylinder opposed engine, and the sixth the four-cylinder job as it is now made by the Moline Plow Co.

The Allis-Chalmers Mfg. Co. also makes a two-wheel front-drive tractor, illustrated in Fig. 15. Its machine, however, is considerably lighter than the Moline tractor and differs from it principally in details of construction. An experiment that J. F. Max Patitz of the Allis-Chalmers Co. tried is rather interesting. This consisted of

taking two of the regular jobs, hitching them together back to back, as shown in Fig. 16, and driving them in one direction as a single unit. In this manner it was possible to get a machine that one man could operate and that was capable of pulling a three-bottom plow under ordinary conditions; otherwise, it would take two men and two single-bottom 16-in. plows. There is possibly an idea in this experiment that is capable of further development. There is no particular difficulty in getting two separate engines to operate together and, if one started out with the idea of making a two-engine four-wheel-drive tractor capable of being broken-up into two units, each of which could be used for cultivating, the result might be a very satisfactory solution of the farm-power problem. It would at least follow along the line of present practice with horses, where five or six horses are used on a two-bottom plow and only two horses on a single-row cultivator.

Cultivation Obstacles

S. L. Allen & Co., Inc., of Philadelphia, also did much work with the two-wheel front-drive type of tractor, designed for cultivating and plowing. Although their experience resulted in their deciding to give up the idea, so far as they themselves are concerned, their conclusion as outlined in a letter from C. J. Allen, is of interest.

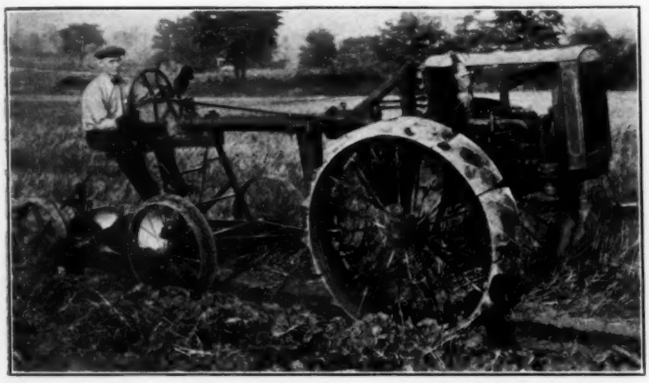


Fig. 15—A Two-Wheel Front-Drive Tractor Pulling a Two-Bottom 24-In. Disc Plow

> Our original idea in building a tractor was to design and manufacture one that would primarily be a cultivator, not too large nor too small, nor too cheap, and handle the large row crops, such as corn, potatoes, beans, beets, etc. After analyzing the situation the two-wheel type seemed to have the best possibilities as a cultivator unit and at the same time the advantages of being adapted to plowing, discing, fitting, seeding, harvesting, hauling, etc. From the endless number of jobs such a machine could accomplish, it appeared to us it would make an ideal one-man general-purpose tractor and take care of all the work on small farms from 25 to 75 acres; and, in addition, be right for light work on any large farm for the same purposes. With the wheels adjustable to 36, 40 and 44 in. to give as much plant clearance as any light-weight tractor of 2600 lb. with wheels 44 in. in diameter and a 7-in. face, a reasonable turning radius, a Le Roi engine and Hyatt bearings throughout, combined with a single and double-row cultivator, the job looked very easy. In addition to these features the market for this type was large and the cultivating not unlike that of the past.
>
> Our tractor, which is illustrated in Fig. 17, was developed with the assistance of the Hyatt Roller Bearing and the McVicker Engineering companies in a very neat and complete form and apparently was capable of accomplishing everything on the farm. Plowing proved easy under favorable conditions; in sandy soil not so good; in hard clay there was scarcely enough power, and on slight grades or poor traction a failure.
>
> The plow was not all that could be desired. It was difficult to hitch up properly and dangerous for the operator's feet when it lifted out of the furrow, and it required a number of depth adjustments throughout the field. If the wheels of the plow were larger and had wide tires the discs and harrows could be attached to the rear of the plow and the ground fitted for seeding without making any change. The present weight of the plow and the operator, combined with the thrust of the tractor beam, made the above hitch impracticable. Removing the plow and replacing the rear carriage on the tractor is hard work and requires two men to do the work satisfactorily. If all the plowing, fitting and seeding could be done without any change of the plow considerable time could be saved while putting in the crops. In some cases, of course, it might be necessary to put the cultivator on before all the ground was seeded. If plowing was all finished the cultivator would answer as a carriage for discing and preparing the seed bed, as the tool bars could be removed if in the way.
>
> Our principle of two-row cultivation has always been to straddle and cultivate thoroughly the center row and finish half of the row on either side. This is practical when two and four rows are planted at a time and has the advantage that it can be used as a one or two-row cultivator by removing the outside teeth, which is very helpful in early cultivations. The same principle was followed out in the power cultivator, with the exception that the pivot wheels were omitted. This added complications, as it was necessary to float the tool bar from side to side at least 6 in. and at the same time be able to expand and contract the outside tool bars. This increased the expense and was not entirely satisfactory, as it was not so easy to accomplish when the tractor was in motion and the teeth were in the ground. The

Fig. 16—A Duplex Tractor Made Up of Two of the Units Shown in Fig. 15

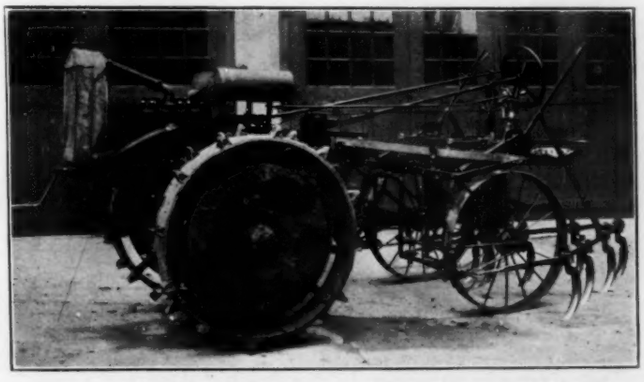


Fig. 17—A Two-Row Front-Drive Tractor and a Two-Row Cultivator

Production of This Machine, Which Was Developed as a One-Man General-Purpose Tractor To Handle All of the Work on Farms Ranging from 25 to 75 Acres in Size, Has Since Been Abandoned

single-row cultivator would not require the expander levers. It would therefore be cheaper and we think that it is the best cultivator for the average small farmer.

The special four-row beet machine, suitable for rows spaced from 20 to 24 in. apart, proved to be the best combination. Two acres per hour were satisfactorily cultivated when traveling at 3 or 3¼ m.p.h. The steering was easy and accurate, even when the hoes were set as narrow as 4 or 5 in. apart; in fact, the higher the speed the easier the guiding of the tractor and the cultivator. This accuracy was only secured after offsetting the seat and placing a pointer over the row. This arrangement gave an extended view of the row and watching the pointer gave the operator the exact location of the tractor.

Cultivating corn and potatoes was much more difficult. Deeper cultivation made the gangs harder to steer and the heavier drawbar pull made the tractor more headstrong. When the crop is small it is necessary to watch under the machine, and more accurate work could be accomplished by offsetting the seat and applying a marker under the tractor to point at the row. Under the most favorable conditions the driver had a busy time to do good cultivating. In the later cultivations the guiding proved easier, as the teeth were set wider apart.

The steering gear of the tractor should have little lost motion, so that the wheels can be held and driven like an automobile. Half a turn of the steering-wheel should be sufficient for guiding the machine down the row.

Faults or features that might be improved upon are as follows: This type of tractor is necessarily built high to get enough clearance. This makes the machine too high to see over, not high enough to see under and too wide to see around.

At best the tractor is hard to drive straight and keep over the row, and this is the secret of all good cultivating. Drive the tractor right and the cultivating will take care of itself. There are three chances to one of getting off the row when operating a tractor, one chance to the right, one to the left, and the third from side-slipping on hillsides or overloads. The moment one wheel slips more than the other this steers the machine out of the row. The last point, together with a little lost motion in the steering arrangement, seems to make the two-wheel tractor somewhat of a "wanderer," and as it has no horse sense to help out, the moment the thoughts of the operator wander the tractor does likewise.

Turning with this type of machine is rather slow and hard work if the right cultivating ratio is used on the steering-gear. To overcome this we designed a two-speed steering-gear, one for cultivating and the other for turning. This appears to us to be a necessary feature. Small farms seldom have headlands large enough to turn without backing. The customary way of skipping a few sets of rows, as is done with a team, should be followed by the tractor driver.

Fields with low land or wet spots also cause trouble. Sand is no place for a two-wheel tractor; neither are slight grades, which the farmer counts as level ground. The width of the wheel setting has considerable to do with the drawbar pull delivery. If possible the rear carriage should be eliminated and the cultivator used for this purpose, thus avoiding extra changes.

The term "one-man" tractor is a misnomer, as it is not practicable for one man to change implements weighing 400 to 700 lb. The sales argument that all the machinery now on the farm can be readily and satisfactorily attached to the tractor does not agree with our experience. Two-wheel tractors should balance when the beam has nothing attached, or a slight overweight in front will do no harm.

To size up the situation from our standpoint it would seem that there is room for great improvement on this type of machine, and although the field is large and the machine can be applied to numerous jobs, we think there are other types of tractors that are better from the cultivating standpoint. The development to date seems to prove that the single-purpose tractor cultivator has made the best progress so far. There is still a difference of opinion regarding these machines, as some have a steering caster wheel in front and rear drive, while others have the front steering drive with a caster wheel in rear.

It would seem that the general-purpose tractor is decidedly on the wane and that the tractor which is made up for one or two kinds of work will be more satisfactory and have a better sale than a machine that is supposed to do everything on the farm with all the old machinery that may be at hand, but not do any of it well. It seems to us that the horse will always have a place on the majority of farms, although there are some types of farms that can be completely motorized to advantage. The fact that the farmer tries to do the most difficult operation on the farm with a tractor is the cause of a number of tractor failures. What the farmer should do is to plan his farming so that the tractor gets the job for which it is best adapted and saves the most, and let the horse take care of the odd and more difficult ones.

Crawler Type General-Purpose Tractors

One of the early attempts to break away entirely from the conventional tractor and to combine in one high-power machine, the ability to handle all of the horse-drawn implements was made by the designers of the Bates Steel Mule that was placed on the market first in 1915, H. H. Bates says that they started with the idea of building a machine that could be used for every essential operation on the average 160-acre farm. This, of course, included plowing, planting and cultivating corn, as well as seed-bed preparation and harvesting of small grains and a sufficient amount of power for belt work, small grain separators, silo fillers, feed mills and the like. The idea was to produce a machine that could be used every time power was required, every day in the year. In the 3 or 4 years that this machine was on the market, several thousand were sold and a large percentage of them are still in use at present. I have always considered that this machine had some very strong fundamental advantages but, like everything of the sort, it also had its limitation. A view of one of these tractors breaking prairie sod is shown in Fig. 18.

As to this, I quote from a letter recently received from Mr. Bates, as follows:

> Being like a three-legged milk-stool, it would get a streak and lie down on its side now and then, whenever the ground was too rough. However, I do not believe it is any more bulky than the Fordson tractor, which has a tendency to roll back on its ears whenever it feels a little temperamental. It was a little awkward to turn around in the cornfield but, at that, it did not knock down any more corn than horses ordinarily do. As a matter of fact, where the land was nearly level, this tractor could do more work with one man than anything that we have ever seen. There was one big drawback, and that was the fact that it looked so different from the usual run of tractors. The farmer had to have a strong imagination and a will of iron to buy it in spite of his neighbor's opinion. Other tractor salesmen would come around and talk to him and after about 10 of them, following one after the other, pointed out to the farmer the difference between the conventional tractor and the one that we were trying to sell him, he had to be the kind of a fellow

FIG. 18—THE BATES STEEL MULE TRACTOR BREAKING PRAIRIE SOD This Tractor Was First Placed on the Market in 1915 and Its Production Ceased in 1918

who, watching a regiment go down the street, saw everybody out of step except his own son Jim.

OTHER TRACTOR TYPES

The Bean Trackpull, which also made use of a single crawler, was built about the same time as the Bates Steel Mule. The design was originated by Alfred Johnson, whose tractor experience goes back to the earliest days of the industry, having designed the Toe-Hold that was built originally by the Joshua Hendy Iron Works in California and, in the early days of the Rumely boom, purchased by the latter company. Mr. Johnson's little single crawler job was built by the Bean Spray Pump Co. of San Jose, Cal. The latest model was shown at Wichita in 1919. Instead of having the steering-wheels ahead as

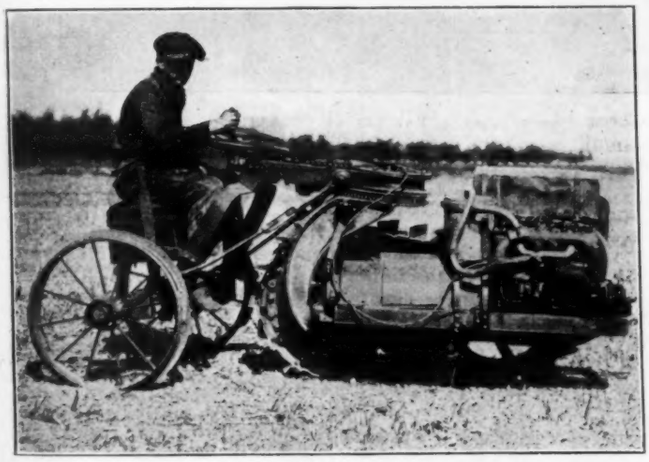


FIG. 19—THE 1917 MODEL OF A SINGLE-CRAWLER TYPE TRACTOR IN WHICH THE ENTIRE POWERPLANT WAS TURNED IN STEERING

in the Bates Steel Mule, this job turned the entire powerplant somewhat the same as the Moline or other front-wheel-drive machines. One of these machines is illustrated in Fig. 19.

At about the same time that the Bates and the Bean tractors were brought out, some experimental work was done on a little tractor that, it was believed, would combine some of the advantages of the Moline and of the crawler drive in one machine. The job was made 30 in. wide overall and was intended to go between the corn rows, using a standard two-row horse-drawn type of cultivator to be operated from the seat of the implement the same as when using horses. Having an endless track, the machine was stable fore and aft, and the implement was subjected to no reaction on account of down-thrust on the rear end. The channel bars extending to the rear were a sort of rudder, since the entire powerplant had to be swung around a pivot for directional control; they also served to carry the steering-wheel and the clutch and the gearshift levers, as shown in Fig. 20. The tractor was driven by a 3⅞ x 4½-in. four-cylinder vertical-engine, and weighed complete just under 2000 lb. without water, oil or gas. Dynamometer tests showed a satisfactory sustained drawbar pull of 1700 lb. in ordinary stubble-field plowing, that is, where the ground was in normal condition for plowing and not slippery on the surface. It would pull a regular two-bottom 14-in. plow and,

FIG. 20—AN EXPERIMENTAL TRACTOR IN WHICH THE OPERATOR RODE ABOVE THE IMPLEMENT ON A CHANNEL-BAR EXTENSION AND CONTROLLED THE POWERPLANT THROUGH TWO LONG LEVERS AND A HANDWHEEL

under an actual plowing test, showed a remarkable gasoline economy. As a cultivating proposition, however, it was too much of a strain on the operator to watch the machine and the corn simultaneously. It was possible to cultivate with the rig, and much actual work was done with it but, had these ever been built, I am afraid they would have proved to be man-killers in the field, because there was not latitude enough for the front end. On paper, a clearance of 6 in. on each side appears ample but in the field, especially after the corn grows up a little, there seems to be no room between the corn rows for a machine 30-in. wide. The job had another limitation, due

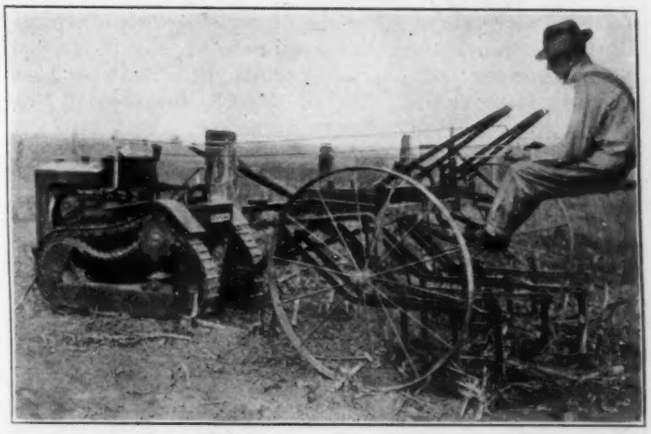


FIG. 21—A COMBINATION OF TRACTOR AND TWO-ROW CULTIVATOR THAT IS CONTROLLED THROUGH THREE LINES, TWO FOR STEERING AND ONE FOR OPERATING THE CLUTCH

to the narrow width; it would lie down if the operator got absent-minded and let the tractor get into a furrow on one side. Being light, it was not much of a trick to right it and probably, after an operator got accustomed to the machine, this would not happen very often. This job was purely experimental and work on it was dropped in 1917 on account of the war. I mention it principally because it shows what is possible along this particular line.

The Cleveland Tractor Co., in addition to its first three-plow model, has brought out a smaller machine comparatively recently and has designed a number of special implements to be fitted to this tractor for cultivating and other special jobs. My opinion is that, in putting the cultivator shovels ahead of the tractor, the Cleveland people have placed them in the most advantageous position for this type of machine, and that it is possible to carry out a satisfactory development along these lines. I have noticed, however, within the past several months, that a new development has been announced. This consists of the small Cletrac with the American Seeding Machine Co.'s two-row cultivator hooked-on behind; the tractor is arranged with a pair of lines for controlling the steering and a third line provided for operating the clutch. Evidently this scheme has been thoroughly tried out and future developments along this line will be followed with considerable interest. It perhaps indicates a tendency toward using lines for tractor control, leaving the operator on the seat of the implement instead of riding on the tractor. A view of this combination is given in Fig. 21.

FIG. 24—THE PARRETT EXPERIMENTAL FOUR-WHEEL LINE-CONTROL TRACTOR PULLING A MOWING MACHINE

FIG. 22—ANOTHER LINE-CONTROL TYPE OF TRACTOR PERFORMING A VARIETY OF OPERATIONS
At the Left the Tractor Is Shown Pulling a Manure Spreader, in the Middle a Two-Row Cultivator and at the Right a Binding Attachment

UTILIZATION OF EXISTING FARM EQUIPMENT

The LaCross Model-M tractor, shown first, I believe, at Wichita, in 1919, is another of the strictly general-purpose type of tractor that have been designed to do all of the farm work and to utilize existing horse-drawn equipment. The mechanical details of this machine are probably very well known, the engine being a two-cylinder horizontal type with a ball-bearing crankshaft, and an internal spur-friction type of drive. An idea of the variety of work that can be handled by this machine is brought out in Fig. 22.

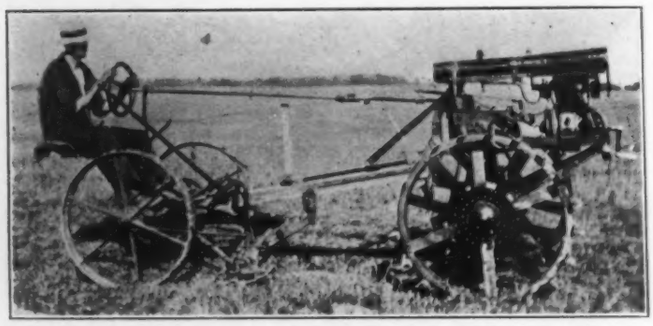


FIG. 23—THE PARRETT EXPERIMENTAL TWO-WHEEL TRACTOR PULLING A MOWING MACHINE

L. W. Melcher, who was chiefly responsible for the design, has written as follows regarding his experience with the machine:

> During the early development of farm tractors not much attention was given to the diversified uses to which they might be put. They were constructed primarily to pull plows and tillage implements of the larger sizes, with little consideration given to the possibilities for a greater field of usefulness. The writer attempted to analyze the possibilities of a more general-purpose machine, and the research work which we did resulted in the following ideas:
>
> First, that a general-purpose tractor must be adaptable to all of the work which has to be done on a farm. Through the cooperation of the farmers and the implement manufacturers over a great number of years, it has been possible to perfect a line of implements which are satisfactory for the tilling, cultivating and harvesting of the various crops which are being produced by the American farmer. We started out with the theory, and still believe that we were right, that a tractor should be built to operate the present tools, rather than attempt to build a tractor first and then the tools around it. We hoped by this method of construction to profit by the many years of development which have gone into farm tools. It did not appear reasonable to us that a producer of a new type of implement would be able to develop it to as high a degree of perfection as the line of tools which had already been developed. There is no question that such an improved line could be developed, but it would take a great many years of practical use to prove that this new line would be an advantage over the existing type. Further, it would require the purchase, by the farmer, of an entire new line of tools developed for use with a tractor. It would necessitate an initial investment for a great quantity of additional equipment. We therefore concluded that the best policy would be to construct

simply a mechanical team of horses, which would replace the animals now in use in every way possible, but which would operate at a greater speed and with more economical results.

The size of the tractor should be comparable with that of the implements which are now in use. Our investigations led us to believe that the average farm which could successfully use this type of tractor is, at present, using 5 horses constantly. The farmer may carry a reserve number but he would not use at any time more than 5 horses; therefore, our mechanical horsepower should be capable of operating the various implements which come within this range.

The control of the tractor necessitated considerable thought. When one considers the various positions which the operators of present-day implements have to assume, it is obvious that the connection between the operator and the tractor must be extremely flexible. For instance, the operator might be upon the top of a load of hay or on a harrow cart or on a binder seat, or any one of a dozen other places where the operator must ride on the implement to operate the various adjusting and control levers. Often, his position must be changed constantly; for instance, in pulling a load of hay with a hay loader. He is, to start with, on the rack and, after he has completed his loading, he is at least 7 or 8 ft. higher than his original position. The operator must be at all sorts of angles and distances from the tractor; it must be possible to shift quickly from one implement to the other, and the control must be positive in action at all times. We decided that the lines similar to those used with horses offered us the best solution to this problem.

The next problem was the construction of the control unit on the tractor itself, which would answer all the purposes required and, at the same time, be sensitive in operation. There were many ways of accomplishing this by using three or more lines but, realizing that the farmer was accustomed to only two lines, we limited ourselves to this number. Further, it was necessary to develop the control so that the lines would be used exactly the same as when driving horses. As a proof that we accomplished this very successfully, we often offered the control to men who had not previously seen the machine, asking them simply to start out as if they were handling horses. In all cases, they started and steered the tractor satisfactorily.

In the LaCross Model-M tractor we used a distinctive design of friction transmission. I wish to say, however, that, with the line control which we developed, it is not absolutely necessary to use a friction transmission. But we were thoroughly sold on the possibilities of this type, because it was easy to control with the lines. Due to the limited distance to which the lines could be pulled, it was necessary to arrange the friction drive in such a manner that the contact pressure was regulated proportionately to the power transmitted. We accomplished this by interconnecting our drawbar and control device so that, in starting a load for example, when a 100-per cent additional pressure is required on the friction drive, we obtain this additional pressure through the resistance at the drawbar. As soon as the load was under motion, the amount of power required to pull the load was reduced and the friction pressure was also reduced proportionately, this feature being automatic at all times. Adequate clearance of the tractor for cultivation of row crops is essential; in this machine, we had a minimum of 31 in. For short turning at the end of rows, we utilized a differential brake which was interconnected to the steering device. The angularity of the front wheels controlled the differential brake, applying it in such a manner as to give the required control for short turning. After constructing some 800 of these machines and placing them in various sections of the country, I can sincerely say that I believe a machine of this type will give the American farmer what he desires in the way of an economical power unit, which can be attached readily to all of the tools which he now uses.

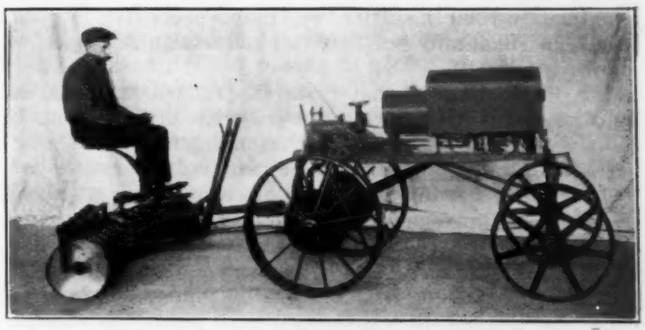


FIG. 25—THE CULTOR, A DEVELOPMENT OF THE MACHINE SHOWN IN FIGS. 23 AND 24 WITH LINE CONTROL DRAWING A DISC CULTIVATOR

Comment on Mr. Melcher's communication is perhaps superfluous although it may be pertinent to say that the American farmers have an investment of more than $3,500,000,000 in farm implements and machinery; therefore, there probably is something in Mr. Melcher's contention that the tractor should be made to utilize existing horse-drawn tools.

RECENT GENERAL-PURPOSE TYPES

At the 1922 Tractor Show in Minneapolis, Dent Parrett exhibited his little general-purpose tractor that he called the Cultor. Mr. Parrett's two-row cultivator has been mentioned previously, a limited number of them having been built in 1916. The two-row cultivator was discontinued and Mr. Parrett started to develop a light two-front-wheel-drive tractor, more or less along the lines followed in the Indiana and the Allis-Chalmers tractors. He figured that it might be possible to make this much lighter and cheaper than anyone had done before; therefore, he utilized a small two-cylinder air-cooled engine of about 9 or 10 hp. and built a machine that weighed ap-

FIG. 26—CULTIVATING YOUNG CORN WITH A GENERAL-PURPOSE TRACTOR

This Tractor Is Intended for Use with a Number of Specially Designed Tools That Are Capable of Direct Attachment and Has an Extension Steering-Device

proximately 1000 lb. This two-front-wheel-drive job was used experimentally for two full seasons in the field, as shown in Fig. 23.

Mr. Parrett states that their experience was that, so long as their own operators were with the machine, it did the work in a highly satisfactory manner. Its most serious limitation was that some care and discretion had to be used in getting the job hitched-up to the standard horse-drawn implement. In working out their hitches for this machine, it was the intention always to utilize the regular tongue of the horse-drawn implement when possible. To anyone who thoroughly understood how to make the hitches, it was a very easy matter to change over from one machine to another. The average time was 10 min. and it was often able to do it much more quickly. However, Mr. Parrett says that when they left this machine in the hands of the farmer, he almost invariably got into trouble with his hitches. After spending much time along this line, Mr. Parrett became convinced that specially built implements for the rear end

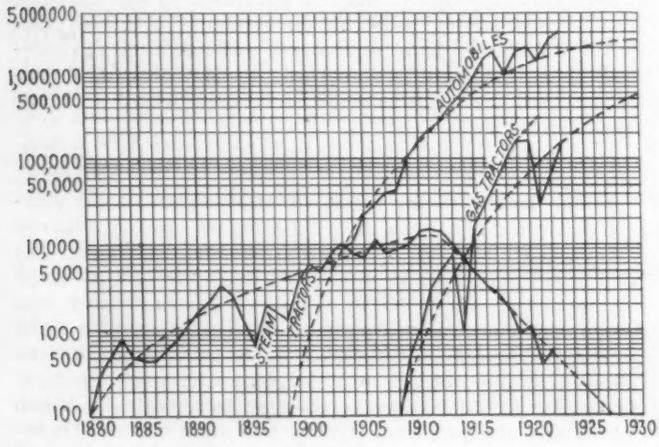


FIG. 27—DIAGRAM SHOWING THE PRODUCTION OF AUTOMOBILES AND STEAM AND GAS TRACTORS

would be required to make the two-front-wheel-drive type successful so that there could be no possibility of going wrong when shifting from one implement to another. Mr. Parrett felt that this was not possible for the type of machine that he was trying to evolve, because one of the first things he set himself to do was to make a tractor that could be used with the existing farm implements. He finally conceived the notion of extending the framework forward, putting on two front wheels and hooking these up with the simplest kind of a line-drive for steering. These lines were arranged so that, when both of them were pulled back, the clutch would be released and latched out. A slight jerk on the lines and dropping them forward would engage the clutch; then, a right or left-hand pull would steer the front wheels in the usual manner. They did not attempt to complicate the line drive by including gearshifting. Mr. Parrett states that it is so seldom necessary to back-up in the field that the operator can get off and go to the tractor if he wants to shift into reverse. However, if desired, a third line can be attached to the gearshift lever and the control of the forward and the reverse speed be carried back to the implement, wagon or whatever is being operated, as shown in Fig. 24.

In its present form, the Cultor has been used two seasons in the field and, with the small two-cylinder air-cooled engine, has been found to be very satisfactory for any of the jobs ordinarily done around the farm with a team of horses. The machine weighs only 1200 lb. and will pull a mowing machine, a binder, a hay rake, a single-row cultivator, or, under favorable conditions, a sulky plow, that ordinarily would require three horses. A view of this machine is given in Fig. 25.

Another machine of the general-purpose type, having a high center clearance and a rear-wheel drive, has been on the market for the past 2 years; it is made by the Rock Island Plow Co. It is my understanding that this machine is the outcome of the company's experience with a double-row power-cultivator. The present job, however, is carried considerably beyond the single-row power-cultivator stage and, while not a great quantity of these have been sold, the experience to date is very encouraging and the Rock Island company believes it has a machine that will actually do everything that is to be done on the smaller farm up to 100 acres in extent.

Being an implement manufacturer, this company has worked out a number of directly attachable tools to be used in connection with this tractor, one of which is illustrated in Fig. 26. It has also developed an extension steering-device for use with a binder and similar tools. Having a friction drive, it can control clutching and declutching for both forward and reverse with a rope running over a pulley on the tractor frame and attached to the friction-drive lever. The initial engagement of the friction is accomplished by pulling one rope after which the pressure is maintained proportionate to the drawbar pull by the helical gears on the friction disc shaft. So far as I know, this machine is the latest development of the general-purpose idea to be placed on the market and its further progress will undoubtedly be watched with considerable interest.

For the past 5 or 6 years, the International Harvester Co. has done an enormous amount of work in its experimental department, looking toward the solution of the general-purpose-tractor idea. Some of the ideas along this line were presented to the Society two years ago, at the Tractor Show at Columbus, Ohio. No resume of the subject would be complete without taking the International Harvester Co.'s experimental work into consideration.

A final point to make in regard to the tractor industry concerns the speed with which the development has taken place. The development of our railway systems, the evolution of the grain binder, the perfection and utilization of the telegraph and the telephone and the enormous development of our various manufactures are all spoken of as the marvelous achievements of the past century. The motor car, the radio and, to a certain extent, the airplane are already considered the outstanding marvels of new development in the present century. I sincerely believe that, within the next decade, the development of the farm tractor and the motorization of American farming will prove to be a more spectacular development than any of the other things mentioned. We who have been working on the tractor problems are perhaps somewhat in the position of the man who could not see the forest because of the trees. It is perhaps a little difficult to stand to one side and get a proper perspective of what has already taken place in the industry. We realize more or less distinctly that the changes in ideas, the development of new types and the discarding of them have been, kaleidoscopic, to say the least, I wonder how many of us have realized how extremely rapidly these changes have taken place and how the idea of power farming has spread from one end of the Country to the other.

A chart[4] was published recently that shows the growth

[4] See *Automotive Industries*, Feb. 22, 1923, p. 360.

of the automobile industry since 1903. I have found considerable enlightenment in plotting on this chart such statistics as are available in regard to the growth of the tractor industry. From 1915 to 1919, the farm-tractor business in this Country was multiplied by 10; that is, from a production of about 15,000 to one of 150,000 per year. The time that corresponds more nearly to this in the development of the motor car was the period from 1905 to 1909. During this time, the production figures change from 20,000 to 100,000, *only one-half the rate of development shown by the tractor industry.* This chart showing the production of automobiles and steam and gas tractors is reproduced in Fig. 27.

Anyone can project the tractor curve for the next 10 to 20 years, but I am willing to go on record that, given a tractor with which it is possible to do all of the work that must be done on the farm, a production of over 1,000,000 tractors per year would result. Further, I believe it will be possible to reach this figure in less than 10 years if the tractor industry will take the information already available and evolve, within the next year or so, a type of machine with which this specification can be met. I believe the limitation lies with the tractor industry and particularly with tractor engineers, and not with the farmer, so far as adopting tractors for general work on the farm is concerned.

STEEL

(*Concluded from p.* 586)

(2) To modify the condition in which the carbon occurs

(3) To remove occluded gaseous impurities

(4) To combine chemically with the iron or the carbon, or both

(5) Either combined or free to form isomorphous solutions with the iron or to separate into distinct microscopic particles

The exact manner in which the added elements influence the iron-carbon system so as to produce new and useful properties in steel is not yet perfectly understood. Roberts-Austen and Spring found that one metal diffuses into another like salt into water. In general, solubility increases with the temperature. Metals and alloys will flow under pressure. Alloys may or may not react when brought into intimate association by fusion or pressure. Molecular mobility increases with the temperature. Upon the cooling of molten alloys, phenomena suggestive of freezing salt-solutions are observed. The depression of the freezing-point of a metal when another is added to it follows the laws of Coppet and Raoult for dilute solutions, and generally the phase rule of Gibb applies almost as well to the explanation of conditions of equilibrium in alloys as to similar problems in regard to liquid solutions.

We may almost say that the age of steel in the United States began with the development of the basic open-hearth process about 1888. Bessemer steel had been produced much earlier, while blast furnaces and foundries had been in existence in the Country from the early colonial days. We must still recognize that the making of steel is not an exact science. It is rather an art, to which scientific methods may be applied; in its fundamental operations it remains a handcraft industry, aided and guided by scientific control-methods. Young metallurgists are apt to become impatient because the steel-makers cannot manufacture their product 100-per cent perfect. This is the ideal for which conscientious manufacturers strive but which can never be perfectly attained.

If it is commendable to make two blades of grass grow where one grew before, how much more worthwhile is it to make 1 lb. of steel go where 2 went before, by improving the quality and the treatment and adopting a metal particularly suited to the requirements. Here we have real conservation in raw materials. The higher grades of ore are not believed to be inexhaustible and in making 1 lb. of steel we not only use one-half as much ore but also one-half as much fuel and refractory material as in making 2 lb. Furthermore, if the steel becomes a moving part of a machine, an automobile or an airplane, there will be a saving in motive power during the life of the machine. Sometimes such a thing does not lead so much to conservation as to an extension of use.

NEBRASKA TRACTOR-TEST ANALYSIS

(*Concluded from p.* 594)

Of the 17 that changed equipment, 3 also changed their rating. One of the three machines that withdrew was returned later for test. During this period 47 tractors have been eliminated from the Nebraska field because of their failure to complete tests or to appear for test after having made application.

Tractor builders have benefited in no small way from the reports of the Nebraska tractor tests which have furnished a mass of data never before available for analysis and study by designers. That a better product is one of the direct results of the testing program is indicated by the statistics in Table 1.

TABLE 1—STATISTICS OF NEBRASKA TRACTOR TESTS

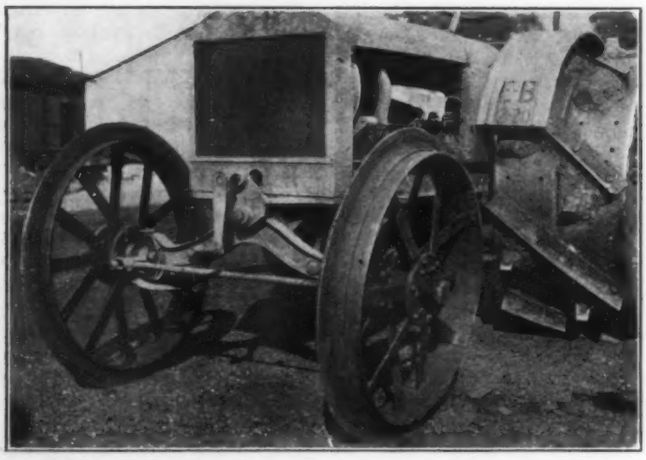
	1920	1921	1922
Percentage of Tractors Completing the Tests and Fulfilling All Original Claims	15.4	40.0	80.0
Percentage of Tractors Completing the Tests Which Could Not Develop the Power Claimed under the Original Specifications	41.5	26.7	20.0
Average Percentage of Increase of Fuel Economy of Kerosene Tractors, Using Four-Cylinder Vertical Engines, Tested in 1922 over Machines of the Same Class Tested in 1920		29.2	

SOCIETY MEETINGS

PROFITABLE CROPS FROM PEAT BOGS

Tractor Types for Reclaiming Waste Land Studied at Minneapolis Section Meeting

That 6,000,000 to 7,000,000 acres of peat land, at present sheer waste, can with proper treatment be made to yield better crops of many ordinary farm products than can be grown on other land, was the astonishing statement made by J. L. Larson at the May 2 meeting of the Minneapolis Section. Mr. Larson, who is a member of the faculty of the agricultural engineering division of the University of Minnesota, and G. R. B. Elliott, also of the University, have made a series of most interesting experiments in the types of tractor, plow and other farm equipment needed to reclaim waste land of the peat-bog variety.



TRACTOR EQUIPPED FOR MARSH PLOWING WITH DEEP SKID-RINGS ON THE FRONT WHEELS AND WIDE EXTENSIONS WITH WIDELY SPACED ANGLE LUGS AND SPADE TEETH ON THE DRIVING WHEELS

In the spring of 1922, a tract of land under the control of the Minnesota Agricultural Experiment Station was being put under cultivation for drainage experimental purposes. Information regarding the equipment necessary for peat-land farming is both meager and conflicting, especially with regard to the preliminary operation of breaking and preparing the first seedbed. The opportunity was therefore taken to obtain accurate information on the equipment required for the heavier operations and the best method of applying that equipment.

DESCRIPTION OF TRACT AND THE EQUIPMENT

The tract selected was several acres of "tamarack swamp" drained with tile the previous fall. Peat on the tract was from 5 to 7 ft. deep and had carried so heavy a growth of trees, principally tamaracks, birch, elm and maple, that it was estimated that 50 cords of stumps to the acre were removed in the clearing. The holes left by the removal of these stumps and the soft spots left by the back-filling of the drains were a very considerable factor in all the cultural operations, more particularly in the first plowing. It was considered that the job was a fairly difficult one, but thoroughly representative of the actual conditions that would have to be met by the farmer in breaking up timbered peat land. During the progress of the experiment, the water level was maintained about 3 ft. below the surface of the peat at the lower end and 4 ft. at the upper end. At the upper end of the tract the soil was fairly firm with considerable sod, while at the lower end the peat was very soft and much torn and pitted by the removal of the stumps.

In the first breaking of any land a very important consideration is the getting rid of trash and soft litter. On peat land it is also especially important to plow sufficiently deep to get under the deep underground root-stalks of marsh vegetation. The greater number of heavy root-stalks, with the exception of those of grass and small sedge, are to be found in the second 6 in. Ten inches to 1 ft. is, therefore, about a minimum depth for first plowing under average conditions on peat swamps other than grass marsh, and plows were chosen that would cut effectively to that depth, namely plows with 16 and 20-in. shares. These in their turn required comparatively heavy tractor equipment.

In all, five types of plow and three types of tractor were used. The most useful type of tractor for marsh plowing, as developed by the tests, is shown in the accompanying photograph, one of the many helpful illustrations Mr. Larson and Mr. Elliott showed as slides. The standing coulter proved most satisfactory for the work on timbered peat land. It is doubtful if the rolling coulter would have been successful in this type of ground, even had adjustments been possible.

An explanation should here be made of what the sod- or furrow-pusher actually is. It is not, as may at first be supposed, merely a mold-board extension. It is a curved steel piece attached inside of the mold board near the point of the plow and extending backward below and behind the mold board on a level with the bottom of the furrow. At the back it is cross-braced against an enlarged and strengthened landside. It was developed largely in cooperation with the Agricultural Engineering Department of the University of Wisconsin, purely as an aid in marsh plowing. Its purpose is to push the freshly-turned furrow still farther to the right, so that the next succeeding furrow will fall absolutely flat and then be pushed tight up against its fellow, completely covering the grass and the litter. The increase in the power required to operate the furrow-pusher was more than compensated for by the very much improved quality of the work done.

SPECIAL WHEEL EQUIPMENT

Ample support to the tractor proved to be just as important as power. One tractor failed signally, not from any inherent defect in the design of the tractor or from lack of power, but because the special wheel equipment that would enable it to do its work was not available. It was like a strong swimmer thrown into the water and told to swim with stones tied to his head and his feet. The special wheel equipment on the successful tractor gave it 50 per cent more power in an emergency than the tractor that failed, although the successful tractor was of lower rating. The spade teeth served a very useful purpose in catching and holding submerged roots or timber in pulling out of a hole. The heavy skid rings gave the driver control of his machine on soft ground. This special equipment is not in any degree complicated or expensive. It can be easily made standard to be attached to the tractor by the operator for soft-ground conditions.

There are many tractors now owned throughout the country that cannot be profitably operated in the early spring or in wet weather. This is especially true in the working of peat land. Yet peat land can be cultivated, even at its wettest without injury to the seedbed. It can be plowed in the spring and seeded while the clay upland is still

too soft. This is an extremely important factor in financing farming operations as well as in general farm efficiency. It seems logical that the wider wheel equipment should be made standard for the wetter and softer districts and furnished upon the advice of the tractor dealer. It is also probable that in many cases where tractors are now unprofitable on soft lands, an expenditure of $100 would change an unprofitable into a profitable investment.

From the standpoint of mere efficiency in turning soil, the cutaway disc loaded to cut 7 in. was far ahead of any of the plows. In fact its power consumption per unit of cross-sectional area turned was less than one-half that of the plows. Its use is, therefore, strongly to be recommended under conditions where its use is practicable. It cannot be recommended for first breaking instead of using plows, for it required about five passages of the disc to give results equivalent to one plowing. The results of the work seem to indicate that disc machinery may be extremely efficient for all later cultivation.

The roller gave some remarkable results. Not only did it pack the peat and so form a better rootbed but, after the ground had been plowed, harrowed and rolled, even that part which was originally so soft and full of holes that it was difficult to get the tractors through it, became sufficiently firm to support horses for all later cultivation.

Several important things were brought out during the trials. What may be called the fundamental consideration upon which all the rest was built up was the better quality of work done by the heavier plows. This was later confirmed by the lessened weed growth on the deep plowing. During the summer, nettles were plentiful on the shallow plowing but not on the rest of the field. Although deep plowing on new peat will not help the crop yield the first year, there is no question that it gets rid of the old growth and puts the land in better condition forever after.

Power Required

Analysis of the power consumption developed several interesting facts. On the larger plows, the drawbar pull was constantly near or above 10 hp. with a reserve up to 17 hp. drawn upon at times. For the smaller plows, the power consumption was above 8 hp. with a reserve up to 15 hp. called upon. From this it would appear that for marsh breaking a tractor is necessary that is capable of developing not less than 12 working drawbar hp. with a reserve above that. This power and reserve is not necessary for later plowing.

In calculating the power consumed per unit of cross-sectional area, the 16-in. plows give almost the same results as the 20-in. plows of the same size. This is not what was expected, as it was thought that the vertical cut would offer a higher proportional resistance than the bottom cut. Apparently this was not the case, for the 20-in. plow gave no greater efficiency than the 16 in. of the same make.

The general proposition was established that for ordinary peat breaking the horsepower required can be figured readily and with fair accuracy on the basis of a 5-lb. pull per sq. in. of furrow-slice. If this is multiplied by the speed it is proposed to travel, the horsepower can be calculated in the ordinary way.

In answer to a question from A. F. Moyer, Mr. Larson said that the larger tractor-wheel diameter had been found better than the narrow or small wheel in work on peat land.

The question of what crops are best suited to peat land brought out some striking facts. Mr. Elliott, whose work deals particularly with crops, reported that about two-thirds or three-fourths of the ordinary farm products will do better on peat land than on other land. The other one-fourth of the list will do better on other land than on peat. Corn, potatoes and rice are good. Wheat will not do anything; but oats will grow about twice as much. Hay grows well and so do all sorts of grass. Onions thrive and will range from 500 to 600 bu. on 6-in. level land per acre. Carrots yield over 600 bu. an acre, sugar beets 20 tons to the acre.

Asked by Mr. Sikes at what speed per hour most effective and efficient work had been done, Mr. Larson answered that 2¾ m.p.h. had been found the best plowing speed, disregarding the number of acres covered per day. The possibility of miring is doubled by running at slow speed, but a very high speed is also undesirable. The bog is like rubber or tar. The faster one moves over it, the less impression is made.

The discussion closed with Mr. Moyer's request that Mr. Larson prepare a curve of plowing efficiency showing the cubic feet of furrow turned per drawbar-horsepower per hour, as a true measure of plowing efficiency, very nearly in proportion to the plowing cost when the depth is considered and human labor per horsepower is fixed.

In addition to Mr. Larson's paper, this last meeting of the season included a showing of the popular film, Electricity in the Motor Vehicle, sent out by the North East Electric Co., and Mr. Scarratt reviewed in detail the National Tractor Meeting at Chicago.

The officers elected for 1923-1924 are all men experienced in Section work and devoted to making the Minneapolis Section a success. Chairman, Victor Gauvreau; Vice-Chairman, A. F. Moyer; Secretary, Phil N. Overman; Treasurer, J. S. Clapper. A. W. Scarratt will represent Minneapolis on the National Nominating Committee at Spring Lake.

FOUR-WHEEL BRAKES DISCUSSED

Engineer Describes Hydraulic System Before the Detroit Section

Malcolm Loughead

A system of four-wheel brakes actuated by hydraulic pressure was described at the meeting of the Detroit Section on May 17. The speaker, Malcolm Loughead, described the important mechanical features of his particular design, answered numerous questions and discussed some of the disadvantages cited against four-wheel brakes in general. The meeting attracted over 200 members and reflected the great interest that is being taken in four-wheel brake development.

The hydraulic pressure in the Loughead system is built up in a cylinder that is mounted near the fulcrum of the brake-pedal. A piston in this cylinder is directly connected to the lower end of the brake-pedal forging and is forced into the cylinder by the depression of the brake-pedal itself. The ratio of the movement of the pedal and the piston is about 4 to 1. Four metal pressure-lines or tubes lead from this master cylinder to points on the chassis frame adjacent to each of the four wheels. Flexible tubes lead from these points on the frame to individual brake-actuating cylinders mounted on each of the four brake-supports. These flexible tubes are made of heavily reinforced rubber tubing or hose with flexible metallic tubing running through its center.

Each of the brake-actuating cylinders contains a pair of opposed pistons, one at either end of the cylinder. These pistons are forced apart by the hydraulic pressure set up in the system when the pedal is depressed and it stands to reason that the pressure on both pistons in all four actuating cylinders must be equal. The brake-bands are of the external contracting type and are pulled together by two short independent levers. One end of each of these levers bears on the head of one of the pistons in the actuating cylinder and the other end exerts a pull on the brake-band end, tangential to the drum, when the brake-pedal is depressed.

Any leakage of liquid from the system is compensated for by mounting a small reservoir on the dash that automatically replenishes the master cylinder. When the master-

cylinder piston is in the off position it uncovers several small port holes that are in direct communication with the reservoir.

Advantages Claimed for Hydraulic Brakes

The speaker made several definite claims of superiority for the hydraulic type of brake over the mechanical type. Since there are fewer mechanical joints in the hydraulic system, the friction loss in the operating mechanism is claimed to be lowered considerably. This advantage becomes pronounced after several months of service, when, due to a lack of proper lubrication, the mechanical brakes show wear in some joints and seizing or binding in others. The flexible connection between the brakes and the chassis prevents trouble due to the improperly related movement of a mechanical brake-linkage. Brake adjustment is not affected by a change of loading in the car. The movement of the body in relation to the axles when traveling over rough roads does not react against the brake-pedal. This condition does exist in some forms of mechanical brake and is particularly noticeable when coasting down a rough grade, the brakes having a tendency to lock and release alternately, due to the spring movement. Pedal pressure in the hydraulic system is moderate. It is not necessary to employ any servo mechanism because of the higher mechanical efficiency, the absence of any lost motion and the large contact surface of the external brake-band.

Mr. Loughead described an accurate method of measuring the distance required to bring a car to a stop. A pistol is mounted rigidly on the car frame and its trigger is connected to the brake-pedal so that the depressing of the pedal 1 in. fires a shot into the road surface. When the car comes to a stop, the distance is measured from the muzzle of the pistol to the point where the shot entered the road. This gives a far more accurate result than depending upon the driver to depress the pedal when he crosses a line or is given a signal. Test results using this method were presented by the speaker for a car weighing 4400 lb. with driver; weight on the front wheels, 2000 lb.; weight on the rear wheels, 2400 lb.; using 35 x 5-in. tires inflated to 65 lb. per sq. in.; and operating on a concrete road.

Braking on	Distance Required To Stop, Ft.
Rear Wheels Only	89.2
Front Wheels Only	67.6
All Wheels	36.8

Mr. Loughead recommended providing approximately 1 sq. in. of brake-lining for each 12.5 lb. of total car weight, fully loaded. Increasing this ratio to 16 lb. results in burned linings and a reduced coefficient of friction.

External Brakes Preferred to Internal

External brakes are preferred by Mr. Loughead for several reasons. When internal brakes are used repeatedly or on long grades, the expansion of the heated drum may reach a point where contact with the lining is not possible. With external brakes, heating the drums results in an increase of available pedal travel. Oil and grease are less likely to leak from the axles onto the external brakes. Due to the fact that both distortion and expansion must be combatted in the internal design, it is difficult to attain a high ratio of pedal movement to brake-shoe movement for a given pedal-pressure.

The liquid used in the hydraulic braking system is a mixture of alcohol and glycerine; 60 per cent of glycerine and 40 per cent of alcohol. The speaker favored having all four brakes adjusted to apply at the same instant instead of having the rear brakes act in advance of the front. If one of the lead lines or hoses leaks or breaks, the system becomes inoperative. About 35 lb. would be added to the weight of a front axle of the Cadillac car by adopting front-wheel brakes of the hydraulic type. The front-axle forging of any car must be redesigned to withstand the braking torque when front-wheel brakes are added. It is claimed that the tire mileage is increased with four-wheel brakes because of a lesser tendency to lock the wheels in ordinary service and a reduction in skidding. Rawhide is used to pack the pistons and prevent any leakage of the fluid from the hydraulic actuating cylinders. The brakes do not need to be relined frequently when used on all wheels since the wear is distributed over a much greater braking surface.

T. J. Litle, Jr., outlined his experience with four-wheel brakes of the hydraulic type, stating that he had found them very effective and had not experienced any serious difficulty due to locking, or because all wheels did not brake uniformly. Clarence Carson took issue with Mr. Loughead regarding the attainment of satisfactory equalization. He said that the wide variation in frictional coefficient of commercial brake-lining upsets the finest adjustment or mechanical equalization by producing a totally different braking effect on each of the four drums, even though the band pressure might be equal. A. L. Clayden discussed the scheme of braking on diagonal wheels, saying that this was done originally in England by the Argyll engineers to insure at least one front and one rear wheel running free in case the other pair locked. It was assumed that having two diagonal wheels free would provide better control of the car in a skid or for steering. This plan is now in disfavor because the increased stopping power with all four brakes acting together is of more practical value for safety reasons than the theoretical advantage of diagonal braking.

HIGHWAYS AND TRAFFIC IN A CITY

Major F. S. Besson Gives Washington Section Results of His Observations

Several newspapers ran front-page accounts of the Washington Section's meeting on May 4 when Major F. S. Besson, acting engineering commissioner of the District of Columbia, spoke on Highways and Traffic, basing his conclusions on observation of the transportation situation in the City of Washington and other municipalities in which he has been studying traffic conditions.

In introducting the speaker, Chairman Warrington reminded the audience of the increasing importance of transportation in an age when we figure not how far one place is from another, but how long it will take to cover that distance. The 40 miles from the City of Washington to Baltimore is now thought of not as 40 miles but as a 45-min. run. Increasing improvement in transportation is responsible for the change in viewpoint, as it decreases the time necessary for getting from one place to another.

Major Besson explained that streets may be divided into three classes: rapid-transit streets, local streets, traffic highways. Rapid-transit streets, if properly laid out, invariably become business streets. The motorist should use them only to transact business. Local streets are residential, commercial or industrial in character and should be used, so far as possible, only for the purpose for which they were designed. Traffic highways exist primarily for hauling and motoring. They should afford convenient connections between residential, commercial and industrial districts, and between the city and the surrounding country. When a traffic highway becomes overburdened, the overflow takes to rapid-transit and local streets. Business people then complain that the congestion on the roadways interferes with the transaction of business. Often the traffic engineer looks no farther than these rapid-transit and local streets for the trouble, whereas it originates in the lack of sufficient traffic highways, and the remedy is to supply more of them.

Traffic Problems in City Planning

From a traffic standpoint, an intersection consisting of more than two streets is objectionable, though from the standpoint of appearance very beautiful effects can be obtained. Where there is sufficient area for the installation of a central circular park, and rotary traffic to the right can be established, conditions are greatly improved. If there is any latitude in making a choice, a car-line street should not pass through a common intersection with two other streets. Where such an intersection of a car line and two other streets is unavoidable, the installation of platforms or

"islands" will be a great protection to pedestrians.

These principles should be remembered in laying out city blocks. For some streets it is desirable to discourage traffic, except that having to do with abutting property. The roadways of these streets should be wide enough for local requirements only and need not be continuous for long distances. For others, through traffic is a prime consideration, and interruptions to safe and rapid travel should be few.

Streets have both horizontal and vertical directions. Only the former have been discussed so far. Vertical directions are usually treated under the heading of grades. No definite rules can be given for the maximum permissible grades. Judgment alone can gain the best results in fitting streets to the terrain. A few cities have examples of street grades of close to 20 per cent. Some rapid-transit streets are known to have grades of more than 10 per cent on which, of course, operation is costly. A street cannot serve satisfactorily as a traffic highway if it has grades as steep as 10 per cent. Even 6 to 8-per cent grades are undesirable, but they may be used for short lengths, if lesser grades are impracticable. If they continue for more than one block, 6 to 8-per cent grades will slow up traffic markedly. Grades of from 4 to 6 per cent are proportionately less undesirable, while any grades up to 4 per cent may be used without hesitancy for traffic highways.

Choice of the Right Grade Imperative

The grades to be adopted depend to a great extent on the nature of the terrain. In this matter foresight is needed, for much money has been spent in correcting at a later date the "follow-the-ground" policies of an earlier design. In the establishment of grades on rapid-transit streets and traffic highways, the needs of traffic are of first importance. On local streets, the needs of abutting property are given greater consideration, though intersecting traffic highways or rapid-transit streets may definitely fix for short distances the grades on local streets.

Whether or not it will be feasible to develop an area often depends upon the grades established for the surrounding streets. While the basis of a highway system of a city should be a rectangular plan, such departures from the plan should be made as will facilitate traffic, aid real estate development and simplify drainage. Real estate operators should be encouraged to develop property along natural lines to the fullest extent of their financial and artistic abilities, as long as traffic and drainage requirements are considered; but in all developments there is an economic limit beyond which it is not advisable to go. In developing ground for the sale of moderate-priced homes, house and lot to sell for certainly less than $30,000, it is generally necessary for the land operator to destroy practically all the native trees. Unless parks are bought and paid for by the municipality, they are such a large burden upon the remainder of the land that none but the very wealthy can afford to buy it. Of course, in out-of-the-way sections of the suburbs of a city, where land will probably never sell for more than 20 cents per sq. ft., it is practicable to set aside a half-acre of rough ground for each dwelling and to keep the trees in their native state. On the other hand, such an arrangement cannot be countenanced where it would interfere with the proper economic growth of the city.

Width a Fundamental Consideration

We must look into the future when we lay out our highways. The width of streets is one of the fundamentals vitally affecting the expansion of cities and, while it is a mistake to make streets too narrow, it is also a mistake to make them too wide. As a large portion of the area of a city is occupied by streets, above 30 per cent of the total area on the average, if they are unnecessarily wide, land otherwise available for buildings is wasted. Space other than that used for vehicles or pedestrians is extra or reserve width. It is provided as a matter of civic pride or to add beauty and comfort, and also to permit the expansion of the roadway and the sidewalks for future traffic.

Widths may vary according to the class of street. Experience shows that in laying out a rapid-transit street, provision should be made for double tracks and, when the business character of the street has developed, there should be available a roadway of at least 54 ft. A total of 54 ft. is the minimum width permitting free passage between street cars and vehicles parked at the curb. This width allows the installation of car-loading platforms, so that vehicles can pass between them and the curbs while the cars are taking on and discharging passengers. The provision of these platforms is important, for they protect persons boarding and leaving the cars and give vehicles a freedom of movement that adds greatly to the traffic capacity of the street. Further widening within a certain range, as for instance to 65 ft., is uneconomical. It is too narrow for three lines of traffic between the track and the curb and serves two lines not much better than a width nearer to the minimum.

For streets of greater importance, a step up to approximately 72 ft. is necessary. This roadway is wide enough to accommodate two streams of traffic between vehicles at the curb and the street cars. Actually, however, such use is curtailed by the tendency of traffic to take the center of the available space in single file. An excellent plan for using a 72-ft. car-line roadway is to stop cars at an angle or perpendicular to the curb. This not only gives shoppers increased parking facilities, but also allows trucks to unload to advantage. At car-loading platforms, vehicles may stop parallel to the curb and still leave a free passageway.

A roadway cannot serve satisfactorily as a traffic highway unless it can provide for two unhampered lines of moving vehicles in either direction. In the development of such a highway, Major Besson believes that an expensive pavement for the full width is not justified in the earlier stages. Using a cheaply constructed pavement for the entire width gives a surface with a probable life of from 10 or 15 years, but with a high yearly maintenance that rapidly increases as the payment grows older and traffic increases. The money spent for such a pavement is spread over a large area, but when a better style is demanded, the old pavement has little or no salvage value. The more economical way seems to be a progressive development from a 9-ft. to an 18-ft. roadway and on through to the final width of 54 ft. One advantage of this gradual development is that construction is paid for in installments commensurate with the volume of traffic that is served.

The problem of pavement design to take adequate care of transportation gross weight is today well in hand. To provide economically for the probable volume of transportation is a larger and more difficult problem. A strong pavement can readily be substituted for a weak one, but unless plans have been exceptionally well made, it is seldom that a wide roadway can be substituted for a narrow one in the heart of the city. Everything possible should be done to realize the full capacity of the roadway width that is available.

Effect of Width, Length and Weight of Vehicles

The use that can be obtained from a given width of roadway depends upon the width of vehicles and this, except in the case of street cars, should be limited to not more than 7½ ft. Permits may be granted for wider vehicles, subject to restrictions as to the routes to be followed and the time of day passage is to be made. The length of vehicles in the near future will also need restriction, especially if the use of six-wheel trucks and trailers develops. An overlong truck is difficult to park without closing traffic lanes, and in turning a corner, the overlong truck is liable to swing out and damage other vehicles.

Not only the width and the length but also the weight of the vehicles must be considered in developing the maximum capacity of highways. It would not be wise to eliminate the 7½-ton truck, for its load would have to be carried by more than one truck. More space would be taken on the highway, increasing congestion and wear, for if two types of truck are equally well-designed, carrying the load on four wheels will do less damage than carrying it on 20. Gross weight alone is not the all-important factor. Speed,

unsprung weight, wheel-loads, character of tires, tractive stress on the pavement, all these enter into the question.

Maximum Traffic Capacity Means Control

Passing on to the control of heavy traffic, Major Besson held up Fifth Avenue, New York City, before and after the installation of the new traffic towers, as an example of what efficient control can do. The present system of treating vehicular traffic between 23rd and 59th Streets as a unit, together with the control of pedestrians, has doubled the capacity of the avenue during rush hours. Today approximately 15,000 vehicles pass in 10 hr.

Major Besson believes that one-way traffic is fundamentally wrong, although under certain conditions it serves a good purpose. If, for instance, two roadways carrying mostly through traffic lead directly between two points, one of them may well be used for travel in one direction and the other for travel in the opposite direction. Ordinarily, however, the system of one-way streets only adds to the congestion of both one-way and two-way streets, the latter generally rapid-transit streets with two-way car tracks.

Suggested Tax on Weight

Within the permissible gross weights for vehicles, certain regulation is, however, required. A basic rule should be that trucks may not carry more than the weights for which they were constructed, and in accordance with which the owners have paid fees in obtaining operating permits. The motor-vehicle industry condemns overloading and builders generally are arriving at a point where they furnish caution plates stamped with the chassis and body weights and the load capacities. In accordance with the data furnished by the builders, the license bureau should make certain that the permissible gross weights are painted on the sides of all cargo vehicles, and fees should conform to these gross weights. The main principle of the suggested rate is that vehicles are taxed on a graduated scale. It may not be absolutely accurate as judged from the pavement standpoint, but it is as nearly so as can be made under the present state of our knowledge. Such a tax, if properly administered, would return more than $2,000,000 a year, at the rate of approximately $10 for a Ford roadster, $16 for an ordinary touring car and $140 for a 7½-ton truck, the maximum limit. The gasoline tax, on the other hand, would be inadequate, unless an excessive tax per gallon were levied.

Major Besson's paper, which was well-illustrated by many slides, was followed by discussion of some of the points raised.

During the business session that preceded the presentation of the paper, A. W. S. Herrington, vice-chairman of the Washington Section for the coming year, was elected to represent the Section on the National Nominating Committee that will meet at Spring Lake during the Summer Meeting of the Society. W. S. James, of the Bureau of Standards, has been reappointed chairman of the Meetings Committee, and P. B. Lum, of the Auto Car Sales & Service Co., is to be chairman of the Membership Committee.

AERODYNAMICS OF MILITARY PLANES

Fundamental Principles of Design Presented to Dayton Section by W. F. Gerhardt

Two hundred members and guests of the Dayton Section were at the Engineers Club on May 1 to hear W. F. Gerhardt speak on Fundamental Principles of the Design of Military Airplanes. Mr. Gerhardt, an aeronautical engineer in the flight test section of the Air Service at McCook Field, covered very thoroughly the problem of aeronautic-engineering technique in the development of military aircraft. Mr. Gerhardt introduced his subject by analyzing a typical modern research problem to determine the logical sequence in which military-aircraft development should be studied, for in this, as in other fields, it is of little use to begin to do a thing before what is to be done is known.

The paper proper began with a discussion of the mark toward which the development of military aircraft is aimed. It went on to analyze the means at the disposal of the aeronautic engineer in the solution of tactical problems, so that designs for military airplanes can be drawn in accordance with the practical demands to be made upon them. After pointing out the general inter-relation of these technical means of solution, Mr. Gerhardt discussed the relative importance of different types of airplane, propeller, engine, armament and other equipment. Passing on to aerodynamics, he demonstrated that the general theory of airplane performance is based upon an analysis of the forces acting on an airplane, and that by this analysis, such quantities as speed, rate of climb, radius and velocity of turn, can be expressed as functions of the airplane's dimensions. The graphic solutions that Mr. Gerhardt has worked out permit the selection of dimensions to secure any performance desired. The designing theorems showing what dimensions of the airplane most affect any given performance were also stated. With these the designer can be sure to make his improvement in the right direction for economical operation. Similar graphs and theorems were shown for the stability and the controllability of the airplane.

Mr. Gerhardt's very valuable paper closed the Section year, as there will be no meetings of the Dayton Section in June, July and August.

ALLOY-STEEL AND BEARING ALLOYS

Crucible Process the Best for Former—Characteristics of Latter Described

At the regular monthly meeting of the Metropolitan Section on May 17 two carefully prepared papers were presented. The first by J. A. Mathews, president of the Crucible Steel Co. of America, dealt with the Present and the Future of Alloy-Steels, and the second by C. L. Landon, chief engineer of the American Bronze Corporation, Berwyn, Pa., was on Copper-Rich Bearing Alloys.

Doctor Mathews said that it is seldom that any process is discovered that cannot be improved upon, but that the crucible process of making steel is an exception and had never been surpassed. The Bessemer process, invented in 1865, is a marvel for quantity but not for quality. The Siemens-Martin or open-hearth process, invented in 1868, is also a quantity process but is superior to the Bessmer in the quality of the steel produced. The fourth and latest process, the electric furnace that very opportunely came into use during the closing years of the nineteenth century just prior to the introduction of the automobile, offers the nearest approach to crucible steel, but seldom equals and never excels it. Crucible melting is not suitable for manufacturing large quantities of low-carbon steels but the electric furnace is ideally suited for this work. Crucible steel will continue to be used for the highest grades of tool steel and the electric furnace for the highest types of alloy-steel. The chief difficulty with the electric furnace is that the furnaces are built faster than skilled operators can be trained; it is not a cure-all for steel troubles, nor an automatic device that can be operated by anyone, regardless of his experience or lack of it. The problem of steel melting consists of melting in the absence of oxidizing conditions and out of contact with the products of combustion. The crucible, practically sealed, gives the nearest approach to ideal conditions; the electric furnace has little to contend with in the way of contact with the products of combustion and little air circulates in the furnace. But the unit is larger and the ingot is larger, which is its first disadvantage, and pipes, seams segregations, blow-holes and surface imperfections increase in geometrical proportion to the size of the ingot. The 4-in. crucible ingot is the ideal size and when the steel is skillfully melted and poured blow-holes and segregations are negligible. The best melted steel should pipe but the pipe should be located near the top and enough metal should then be discarded to get below it.

Present Practice Criticized

Present practice both of making and of using alloy-steels is not altogether sound. Analysis is over-emphasized. Steels of identical analysis may differ widely. Tension tests do not always show the difference. Steels apparently identical differ in brittleness. Comparative analyses must be used with judgment and with much additional information taken into consideration. Many users seem to think they are getting more for their money from the maker who offers a greater percentage of alloy. Steel-making ability rather than chemical analysis should be the determining factor, and the maker should be chosen who makes the best steel of the specified percentage of alloy.

In most cases, sulphur and phosphorus should be as low as possible, but for an equal carbon-content they are less injurious in crucible steel than in other grades. In electric steel low sulphur may be taken as an indication of the success with which deoxidizing conditions have been attained in the working of the heat. Sulphur in steel exists as separate microscopic particles of manganese sulphide and is liable to segregate. Other inclusions, non-metallic and non-ferrous, that may be present in smaller or greater amounts, are not shown by analysis and frequently escape detection under the microscope. Oxides of the very elements used to make the alloy may be present and analysis may show the total amount of alloy present without showing that part of it is an oxide or a silicate. Slag may be finely divided. The effect of inclusions is essentially that of minute internal cracks. An examination of material that has cracked often will reveal that the crack runs through groups of inclusions or has its origin in a segregated area.

During the war very serious trouble developed in material used for aircraft production, due largely to two defects that were christened "snowflakes" and "hairlines." The snowflakes were caused mainly by poor melting and pouring by inexperienced makers. One company was reported to have melted 1000 tons of steel to deliver 100 tons of billets of a certain analysis. In one case it was shown that the snowflakes could be made to disappear by reworking the steel at proper heats. Hairlines are less readily detected because they are usually so minute that they do not appear until the part is finished and polished. They seem to be definitely associated with minute inclusions, drawn out into filaments, from which the included matter falls out during the grinding and polishing. Although their true significance as a cause of failure has not been positively determined, if they were too numerous, appeared stringy or occurred in fillets, crankshafts showing them were rejected. The name "sonims" has been suggested for non-metallic impurities in steel.

Experiments that have been made with chrome-nickel steels that were first class in every particular showed them to be not as sensitive as supposed, and that the material had not been seriously injured by the excessive temperature of drop-forging. Other unusual tests failed to develop any defects. It would be desirable if forms of non-destructive tests could be developed that would tell the true condition of things in the finished part without destroying it or involving the assumption that the material in the part is the same as that of other sample parts that had been tested. Magnetic analysis has been attempted but with small promise of success except in particular instances. Conductivity tests cannot yet be interpreted in terms of other properties.

An investigation of the fatigue of both nickel and chrome-nickel steels has shown that, although heat-treatment raises the proportional elastic-limit and the tensile-strength, it adds little, if anything, to the fatigue resistance. Fatigue failure has been proved to be a progressive failure, starting in all cases in some defect or irregularity of the internal structure or external surface. Freedom from flaws is therefore more important in members that are to be subjected to repeated stresses than in those having few repetitions of load.

The Human Element in Steel Making

The manufacture of fine steel depends on the human element engaged in the making of it and on the exercising of never-ceasing care. This is also true of the heat-treatment of the finished parts. The consideration of a simple alloy-steel in all its properties would call for the following program: (*a*) complete chemical analysis, including elements not usually determined and the included gases; (*b*) the determination of the recalescence and the decalescence temperatures as a basis for subsequent heat-treatment operations; (*c*) a wide series of hardening experiments at a variety of drawing temperatures; (*d*) tensile, impact, vibratory and dynamic tests under all conditions of heat-treatment; (*e*) microscopic tests for investigating the grain size and for determining the constituents present and corresponding to a definite heat-treatment, slag and other inclusions, segregation, ferrite streaks, and the like; (*f*) tests of the magnetic and the electrical properties corresponding to changes in the physical and the chemical condition of the steel; and (*g*) hardness tests by the Brinell and scleroscope methods.

There is little doubt that the electric furnace will be the source of the alloy-steels of the future when the highest quality is demanded. Its principal advantages lie in the facts that easily oxidizing metals like vanadium, chromium and manganese are readily handled and that smaller amounts of them need be handled to give a final minimum of content in the steel; that less of the oxides will be produced and removed from the steel; that sulphur and phosphorus can readily be controlled and eliminated; that as the steel is made in the furnace itself rather than in the ladle, a better opportunity is afforded for the solution, the diffusion and the homogeneity of the product; and that it performs an economic function because of its adaptability for handling and recovering the alloy values contained in scrap.

H. M. Crane said that his experience bore out Doctor Mathews' statement that the steel's being clean and free from non-metallic impurities is in some ways more important than the alloys it contains.

Effect of Tin and Copper Proportions on Bearing Metals

Mr. Landon gave many interesting facts regarding the structure and characteristics of bearing metals, of which, he said, the tin bronzes are the most important. Although they always contain other elements that may have been added intentionally or may be present as impurities, the structure and characteristics of a given alloy may be predicted by the relative proportions of these two ingredients. In solidifying they take a series of crystal forms, each stable under definite conditions of concentration and temperature. At high temperature the mixture is entirely fluid. As the temperature is lowered progressive solidification takes place with a characteristic dendritic or tree-like structure, the arms being composed of tin-rich Alpha crystals in which are imbedded Delta crystals, still richer in tin. This phenomenon of fractional solidification is known as "liquation." If allowed to proceed to an extreme, liquation is very pronounced, large areas of high tin-content forming and producing a condition called "tin sweating." Molten copper and tin oxidize readily. The addition of zinc reduces the copper oxide, forming zinc oxide. Both zinc oxide and tin oxide are more injurious than copper oxide, but they both rise to the surface and may be removed. Phosphorus is a still more powerful deoxidizing agent. The metals in which it is used are called phosphor-bronzes, although the phosphorus-content may be very low or even zero. The brittleness increases with the tin-content, the normal requirements of a "hard cast bronze" being satisfied by a tin-content of from 10 to 14 per cent. If an intensely hard cast bronze is desired, approximately 3.6 parts of zinc may be added to a 14-per cent tin-content. This produces what is known as the Navy H alloy. The addition of smaller amounts to a 10-per cent tin concentration-mixture forms the Navy G and S.A.E. No. 62 alloys. The addition of lead decreases the original homogeneity, the strength and the toughness and provides a new series of metals of specialized characteristics that possess good machining qualities and an ability to "wear in" and "seat" themselves. These characteristics increase with an increase of the lead-content and are not obtained in the harder alloys.

In addition to the copper-tin alloys, copper-zinc alloys, or "brasses," are used as bearing metals, usually in a worked form. Their strength and ductility increase with an increase of the zinc-content up to the limit of the Alpha field. Lead is frequently added to facilitate machining. Alloys with a zinc-content of from 35 to 40 per cent have had a rather extensive use as bearing metals, especially in the smaller sizes. In large sizes a 10-per cent content is frequently used. When it is prepared for cold-working a slight amount of tin is added.

The only condition that must be met in a bearing is the constraining and defining of the motion of one part of a mechanism relative to another part of the same mechanism. Any bearing that performs this function satisfactorily and maintains this condition of mechanical satisfaction for a sufficient length of time consistent wth current practice is satisfactory mechanically, regardless of its type, material or other considerations. If cost and operating requirements also are satisfactory, every engineering condition is fulfilled. As wear is inevitable, the only factors that can be controlled are the total rate of wear and the relative wear between the journal and the shaft. The ability to resist wear depends upon the internal structure of the metal, that is, its molecular cohesion, which in turn depends on the shear strength, the tensile-strength and the density of the material. The relative surface hardness of the journal and bearing should be such as to localize the greater part of the wear on the part that is easiest and cheapest to replace.

Requirements of a Good Bearing-Metal

In the discussion that followed Sam Tour referred to the fact that single pure homogeneous metals, irrespective of strength, do not make good bearing-metals, but that these are composed of intimate mixtures of hard and relatively soft particles of microscopic size. The hard particles support the load and resist the wear when actual contact exists between the bearing surfaces; the soft particles allow the hard particles to adjust themselves to the journal. The soft particles wear down slightly below the surface of the bearing and form slight depressions in which some of the lubricant is held when the surfaces are brought into contact with each other. It is this characteristic of certain alloys to form these slight depressions and provide a means for retaining the lubricant that characterizes them as true bearing-metals. It is not strength, toughness or ductility that does it, but the difference between its component crystals. If a journal were absolutely smooth, true and cylindrical, so that polishing would not be necessary, the journal could be made infinitely hard and would give perfect performance on a lubricant-retaining bearing-metal. But as perfect alignment is not possible the journal must be soft enough so that the bearing will polish it and the hard particles in the bearing must be soft enough so that they will not continue to scratch and wear the journal. The hardest particles should be of the same hardness as those of the journal and there should be a polishing effect rather than an abrasion tendency between the two metals.

Heat conductivity is another important factor. The amount of attention that the bearing will receive must also be considered. If forced lubrication is used bronze bearings would be satisfactory, but if the human element enters a babbitt-lined bearing would be preferable. A bronze bushing is now being made by compressing granulated metals. The powdered oxides of tin, lead and copper, together with graphite in any desired proportions, are compressed into the form of a bushing and are then reduced in an atmosphere of hydrogen. This results in a very porous bearing that when boiled in oil, absorbs from 5 to 6 per cent of its weight of oil and acts as a self-oiling bearing. Another laboratory has taken powdered metals instead of their oxides and compressed them with or without graphite, heating them to a temperature at which they just begin to amalgamate and then boiling them in oil.

H. M. Crane, referring to the use of lead in bearings, described a transmission brake with a hardened brake-drum and shoes of what was called plastic bronze, having a large lead-content. When the brake-drum was not run to a point of extreme heat, even without lubrication a mirror-like polish was obtained on the drum without any wear on the brake-shoes. A single set of liners could be used for 2 years with possibly 1/32 in. of wear. On airplane engines babbitt metal formerly was used, but recently a bronze with a high lead-content has been tried, which apparently can stand occasional metal contact, and because of its greater rigidity and because it is homogeneous, will run indefinitely without disintegration.

The meeting was concluded by a series of motion pictures illustrating the historical development and the modern processes of alloy-steel manufacture.

RACES ENCOURAGE DESIGN PROGRESS

Fred Duesenberg Credits Track with Many Important Engineering Developments

Fred S. Duesenberg

Lessons taught on the speedway and race track can be applied with modification to touring-car practice to very great advantage. This has been the experience of Fred Duesenberg who has made such an excellent record in the design of winning racing cars and engines. He addressed the Indiana Section of the Society on May 3 on Engineering Information from the Race Track.

The struggle for extreme endurance, extraordinarily light weight, great strength and maximum efficiency for a given size of engine, exacts a high degree of engineering proficiency. Proper lubrication stands foremost as a feature of racing design that must always be kept in mind. Mr. Duesenberg listed the outstanding points of design and construction of racing cars in the following order of importance:

(1) Cylinder-head with properly located valves and spark-plug; combustion-chamber form
(2) Pistons; weight, balance and general form
(3) Intake manifolding; design and length are of major importance; size and inner surface contour next
(4) Valve operating mechanism; design of first importance; weight of operating parts next
(5) Valves; size and port area of great importance; lift, second; timing, third
(6) Connecting-rod; balance, weight and design
(7) Bearings; size, lubrication and material of importance in order named
(8) Crankshaft; balance, design and material
(9) Cooling of engine and oil
(10) Exhaust manifold and piping
(11) Rear axle; weight first and design second
(12) Front axle; design first and weight second

All of the details mentioned in this list should receive careful consideration in touring-car design, but the order of importance is materially changed. For example, proper manifolding and carburetion would stand near the top of the list.

Racing cars must be steered easily, they must be properly balanced, the weight must be minimized and much attention must be given to the form of the body to reduce head resistance from the air. Reduction of weight must be made with the greatest care, for this has been a pitfall for many designers. They often drill holes in important parts, taking off from 5 to 10 per cent of the total weight at a sacrifice of from 40 to 50 per cent in the strength. The engine, the gas tank and the radiator must be mounted so that twisting of the chassis will not loosen them. Accessibility is of major importance in racing-car design and in this respect many valuable lessons have been learned that are now applied to touring-car practice. The comfort and safety of the driver must not be overlooked, for an uncomfortable driver cannot conserve his energy and strength for the exacting demands of race piloting.

Why Not an Economy Test?

Mr. Duesenberg predicted that the 1923 Indianapolis race would witness surprising revelations of high efficiency and maximum power. He wondered whether it would not be of material advantage to the industry if some form of economy test or competition could be arranged. At present, very little thought is given to economy in the design of racing engines; maximum power and speed are the only essential requirements.

One great difficulty met in racing engineering is the unreliable reports that the drivers often give of a car's performance and faults. Very often these lead to design changes that are unnecessary and unsound. It is often difficult to trace down the fundamental reason why one car is faster than another. When alterations or adjustments are made, they are seldom made one at a time, so that it is next to impossible to trace the improved performance to any one particular change. Block testing to attain the maximum engine performance is not always reliable. Mr. Duesenberg cited an example where one of his engines had been removed from a car that was acceptably fast, and this engine put on the dynamometer to improve its power output. The power was increased from 84 to 115 hp. by altering the timing, the manifolds, the carbureter adjustment and the lubricating oils. When the engine was again placed in the racing chassis it became necessary to alter all of the block test adjustments to attain a satisfactory performance, but, in the end, the performance was bettered due to certain of the changes that had been made as a result of the dynamometer study.

Unsprung Weight and Large Tires

The reduction of the unsprung weight is important in racing cars. Reducing the weight of the rear axle 25 lb. on one of the Duesenberg cars increased its speed from 118 to 121 m.p.h. In another instance, changing from 34 x 4½ to 33 x 5 tires increased the car speed on the Indianapolis track with a reduction in the engine speed. The cushioning effect of the larger tires prevented slippage and bouncing of the wheels. Mr. Duesenberg credited Jimmy Murphy's Irish grit with a greater part in the winning of the French Grand Prix than the four-wheel brakes with which his car was equipped. Offsetting the crankshaft from the cylinder center ⅜ in. in the opposite direction from that of rotation, was a feature of the Grand Prix cars. This seemed to improve the engine performance at low speeds from 3 to 4 per cent. Murphy was enthusiastic about this feature after the completion of the race.

Mr. Duesenberg's racing experience has shown him that manifold forms have much to do with the engine compression. He cited tests where changes in the length of the extension pipes on the bottom of the racing carbureters had materially reduced the engine compression. Without the tube in place, a maximum compression of 89 lb. was reached at 3000 r.p.m. Replacing the extension tube reduced the compression at this speed to 79 lb.

New Section Officers

The Indiana Section elected its officers for the year 1923-1924 at this meeting. F. F. Chandler becomes chairman; O. C. Berry, retiring chairman, will serve as vice-chairman; Dan Teetor continues as treasurer; and George Briggs brings his enthusiasm and energy into the duties of secretary.

SUMMER MEETING THIS MONTH

Spring Lake, N. J., Scene of Popular Medley of Technics and Sports

The stage is all set at Spring Lake, N. J., for one of the most successful meetings ever held by the Society. If responses to the formal announcement be taken as an indication of the number of reservations that will be made, one may predict that the 1923 meeting will equal the Summer Meeting attendance record. The first three mails arriving after the distribution of the reservation blanks brought in more than 200 applications for rooms. The end of the first week witnessed the passing of the 400 mark. Apparently the seashore, the technical program and the recreational diversions have appealed to a large majority of the members.

All of the details of the Spring Lake program are not settled at this date, but it is possible to make a preliminary and tentative announcement of some of the features. The first day, Tuesday, will be devoted to the meetings of the

Hotel Monmouth, the Society's Headquarters for the Summer Meeting

Standards Committee and a thorough discussion of the recommendations that will be made by its various Divisions. Those who are not involved in the actions of the Committee can become acquainted with the boardwalk, the beach or play their qualifying rounds in the big Society Championship golf tournament. The semi-annual business meeting of the Society will be held in the evening, when the members will be addressed by President Alden and the members-at-large of the Nominating Committee will be chosen. Dancing will follow this business session.

Wednesday will be get-acquainted day. The entire day is being reserved for recreational and social activities. The golf tournament will be gotten underway in the afternoon and the tennis enthusiasts will tune up their racquets. The inter-section baseball series will be opened with two games in the afternoon. The shooters of the clay bird will start blazing away at mock pigeons and madame may display that new beach creation specially purchased for the occasion.

Large-Section Air-Cushion Tires

The session on Wednesday evening will be taken up with a paper on large-section oversize tires by James E. Hale, of the Firestone Tire & Rubber Co. Engineers who have driven cars equipped with these so-called balloon or doughnut tires are loud in their praise of the improved riding quality that is claimed for them. Mr. Hale has found many doubts and questions confronting him in the introduction of the air-cushion tire and he is pointing his paper to answer these, in most instances by presenting quantitative data. Three of the large tire companies have agreed to bring cars equipped with the large tires to the meeting and it is likely that a special demonstration of the riding quality of these cars will be scheduled.

Four-Wheel Brake Session

Thursday morning has been set aside for the study of four-wheel brakes. A technical session will be started early in the morning and will include several papers descriptive of representative types of brakes that have reached an advanced stage of development. These descriptions will be given by engineers representing the manufacturer of each particular type of brake. Following the descriptions and the papers, there will be a general discussion of the four-wheel brake subject by several representative passenger-car engineers. The meeting will then adjourn to the roadway in front of the hotels where a demonstration of cars equipped with and without four-wheel brakes will be conducted. These demonstrating cars will also be available throughout the meeting period for personal inspection and driving by the members. Three companies have made definite plans to co-operate in this program to date and others are being solicited.

Thursday afternoon will be devoted to the annual field day of the Society. The running races and field events will be run off on the spacious lawn directly in front of the hotels and bordering the ocean and boardwalk. The program includes events for everyone; old and young, ladies, men and children. A very fine collection of prizes has been purchased and these will be distributed among the skilled performers.

Head-Lamp Glare

The session on Thursday evening will be devoted to a discussion of the troublesome problems encountered in head-lamp illumination. State laws are far from uniform and have caused serious complications in the marketing of cars. Anti-glare legislation is developing rapidly and effective means must be found to eliminate any cause for complaints by State highway officials. This matter will be the subject of a paper by R. N. Falge of the research staff of the General Electric Co. at Nela Park. He will supplement his paper with an outdoor demonstration of head-lamp adjustment, light distribution, glare measurement, special lenses and reflectors. This demonstration will be worth seeing.

The technical session on Friday morning will be devoted largely to the work that has been done during the past few months in carrying on the Society's fuel volatility study at the Bureau of Standards. These tests are the ones being conducted under the joint supervision of the National Automobile Chamber of Commerce, the American Petroleum Institute and the Research Committee of the Society. The recent work has been devoted to studying the effect of decreasing volatility on crankcase-oil dilution and the findings are of engineering and economic importance. Prof. G. B. Upton will also contribute a paper in this session on recent investigations made at Cornell University bearing upon the improvement of fuel economy. The Bureau of Standards staff will bring one or more of their test cars to the meeting for inspection by the members and they are also planning to demonstrate some of their test methods, notably the determination of the degree of crankcase oil dilution.

The Swimming Carnival

Spring Lake boasts of a very fine still water outdoor bathing pool surrounded by large verandas and equipped with diving boards and platforms for fancy diving. The presence of these facilities was not overlooked by those in charge of the athletic program and, as a result, Friday afternoon has been set aside for the Swimming Carnival. Races, plunges, stunts, diving and all manner of aquatic events will be staged. The verandas surrounding the pool will amply accommodate the large gallery that is expected to watch these water sports. The final game of the Section baseball series will be played directly after the Swimming Carnival. Meanwhile, the golfers, the trapshooters and the tennis followers will be battling for the final honors in their respective fields. All champions must be declared by Friday at sundown.

Friday evening will see the closing of the formal program of the Summer Meeting with the Grand Ball and distribution of prizes. The winners of the all round and Section championships will be announced. The dancing contests featured for many years past will be a feature of the Grand Ball.

For the Ladies and Children

There will be plenty of recreational and social features incorporated in the Spring Lake program for the ladies and children. Card parties will be featured when the men are busy with technical meetings or demonstrations. Motion pictures will be run simultaneously with all evening meetings. Dancing can be enjoyed during afternoon tea and will follow each of the evening technical sessions until after midnight. The kiddies will enjoy digging in the sandy beach that is just across the road from both hotels. There will be athletic events in all branches of sport for both ladies and children. Summer meetings beckon to the entire family.

SPRING LAKE ROAD MAPS MAILED

Through the courtesy of the Hyatt Roller Bearing Co., the members of the Society were each provided with a road map showing how to reach Spring Lake from either New York City or Philadelphia. Jersey is very proud of her State highways and motorists are well cared for, along the coast line particularly. A large fireproof garage of modern type is located directly back of the hotels where the Society will be quartered. Folks from the Middle West will find the Lincoln Highway in good condition and this route is recommended as the most direct way to reach Spring Lake from Chicago, Cleveland, Indianapolis and other cities. Detroiters will probably make better time by taking the boat to Buffalo and driving from that point.

REDUCED RAILROAD FARES

Members Can Travel to Summer Meeting at Fare and Half for Round Trip

All members of the Society will receive certificates with the next issue of the *Meeting Bulletin* entitling them to purchase round-trip tickets to the Summer Meeting at Spring Lake for one and one-half times the regular one-way rate. This privilege is limited strictly to members of the Society

RAILROAD FARES AND TRAIN SCHEDULE FOR SUMMER MEETING AT SPRING LAKE, N. J., JUNE 19-23, 1923

	RAILROAD FARES		PULLMAN FARES				Train Schedule.
From	Fare and One-Half for Round Trip	Summer Excursion Rate	Lower Berth, One Way	Upper Berth, One Way	Drawing Room, One Way	Compartment, One Way	Special Train Leaves Monday, June 18
Chicago	$48.75	$58.78	$9.00	$7.20	$31.50	$25.50	10:30 a.m.
Detroit	39.12	45.68	7.50	6.00	27.00	21.00	1.20 p.m.
Cleveland	30.55	38.14	5.63	4.50	21.00	15.75	6:05 p.m.
Toledo	36.30	45.68	6.38	5.10	22.50	18.00	3:15 p.m.
Cincinnati	40.20	51.06	7.50	6.00	27.00	21.00	1:45 p.m.
Dayton	37.55	47.52	7.50	6.00	27.00	21.00	2:35 p.m.
Columbus	33.75	42.44	6.38	5.10	22.50	18.00	4:50 p.m.
Buffalo	27.05	29.03	4.50	3.60	16.50	12.75	7:45 p.m.
Pittsburgh	23.75	....	4.50	3.60	16.50	12.75	11:15 p.m.

The S.A.E. Special arrives at Spring Lake Tuesday, June 19, at 9:45 a.m.

and the dependent members of their families. The certificates must be validated upon arrival at Spring Lake and the Society staff is not permitted to pass any certificates presented by persons other than those shown to be members by our records.

The table reproduced on this page shows the rate of fare applying from the principal automotive centers to Spring Lake. It also gives the time of departure of the special Pennsylvania train that will bring the Western delegation to the meeting on Monday, June 18. Reservations on this special train should be made through the Pennsylvania Railroad representative in your city or the Secretary of the Section of the Society nearest you. Pullmans leaving the several cities will be assembled into a special train at Pittsburgh and will run direct to Spring Lake in time for the opening of the meeting, Tuesday morning. Members living in the East can travel to Spring Lake conveniently through Philadelphia and New York City, since trains are operated at frequent intervals to the Jersey coast resorts at this season of the year.

Watch the *Meetings Bulletin* carefully for last minute transportation announcements.

MATHEWSON BUFFALO SECTION CHAIRMAN

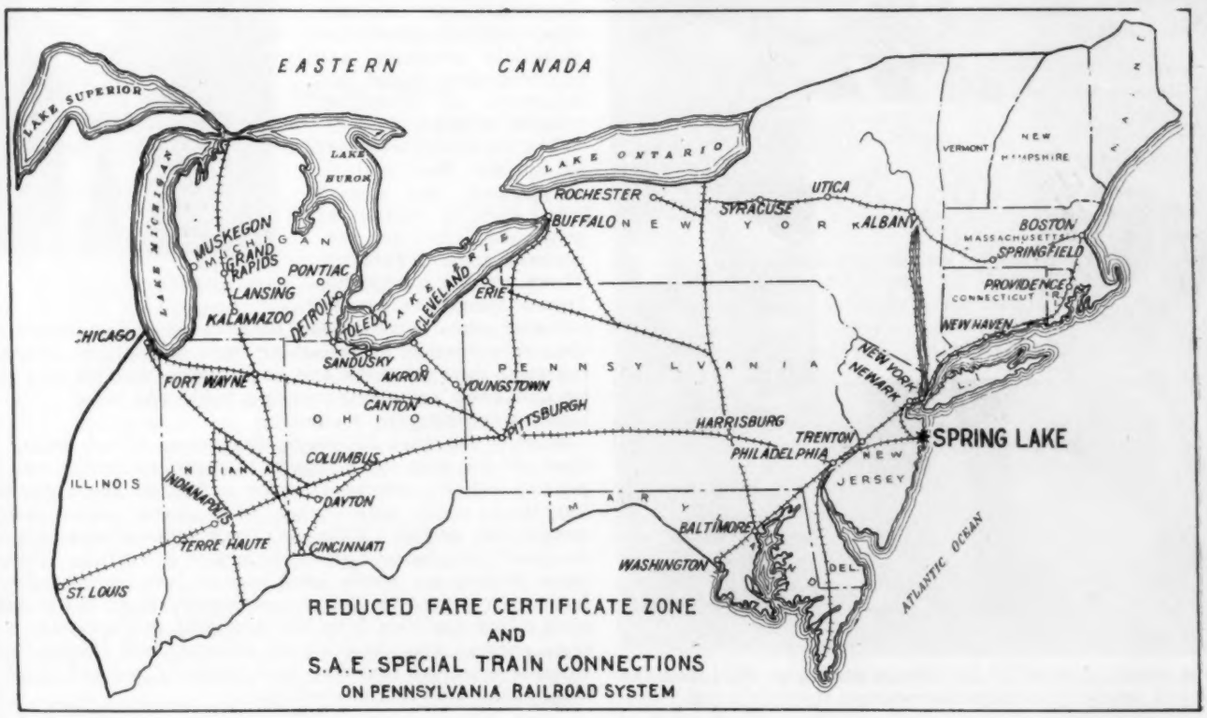
Through an unfortunate error the photograph of Otto M. Burkhardt was printed on p. 507 of the May issue of THE JOURNAL as the newly elected Chairman of the Buffalo Section of the Society. E. T. Mathewson is the Chairman of the Buffalo Section for the year 1923-1924 and not Mr. Burkhardt. However, this provides an opportunity to make proper acknowledgment of Mr. Burkhardt's unusual enthusiasm and active effort in behalf of the Buffalo Section during the year just closed.

CLEVELAND SECTION STAGES FROLIC

Athletes Cavort in Preparation for Spring Lake Inter-Section Contests

The Cleveland Section ended its 1922-1923 year with an out-door frolic and sports carnival on the spacious grounds of Nela Park on May 19. Over 50 members of the Section turned out to display their athletic prowess, and subsequent reports indicate the creation of many sore muscles but no regrets. John Younger and K. B. Britton aroused great enthusiasm among the resident engineers of Cleveland with their cleverly worded and attractively printed announcement of the proceedings. Based on the predictions made therein, one might have expected almost anything. As it was, the contests proceeded on a friendly basis without injury or fatality.

Following a brief business session, several races were run for the youthful and more ambitious members. These were followed by less exacting tests of skill such as broad jump-



L. L. Williams, Secretary; O. A. Parker, Vice-Chairman; John Younger, Chairman; Harry Figgie, Treasurer

THE 1923-1924 OFFICERS OF THE CLEVELAND SECTION

ing, high jumping, shot put and three-legged sprints. L. L. Williams, best remembered for his direction of and participation in the Cleveland Circus at West Baden, staged a golf driving contest but substituted a wooly pellet for the more attractive rubber sphere. The contest attracted several who were uninitiated to the Vardon swing and provoked much merriment at the expense of the contestants. G. H. Madelung, designer of air-gliders, conducted a balloon race that provided time and opportunity for those who wished to blow themselves unto the bursting point.

Harry Figgie, famed underhand hurler of the indoor baseball, marched his choice for Spring Lake onto the ball diamond and challenged all comers. This particular ball game proved to be one worth watching, but hardly conducive to an even temperament on the part of the participants.

Figgie's followers lived up to their reputations and the all-comers were appropriately buried with scientific honors. Babe Ruth Buckwalter swung his bludgeon mightily and Harry Portugal shouted effectively for the winners.

Events of the day were announced to the assembly by K. B. Britton in the role of town crier and general disturber. His costume reflected originality to say the least, but the bell he tolled broadcast the identical refrain of the well-known summoner to the dining board and, in this instance, the latter was only represented by a lone hot-dog wagon whose bill of fare was decidedly limited in variety.

All in all, it was a big day and thoroughly enjoyed by those present. Officers for the year 1923-1924 were elected at the outing. John Younger, who has served as an efficient chairman of the Meetings Committee of the Section, was chosen chairman. Orrel A. Parker, retiring chairman, becomes vice-chairman; Harry Figgie remains as treasurer; and L. L. Williams shoulders the responsibilities of secretary. A substantial balance was reported on hand in the treasury for the conduct of an active program of meetings in the fall.

K. B. BRITTON ANNOUNCING THE VARIOUS EVENTS AT THE CLEVELAND SECTION'S PICNIC

SPRING-SUSPENSION AND SPRING MATERIALS

R. E. Northway Discusses Types and Methods of Treatment at New England Section

R. E. NORTHWAY

At the meeting of the New England Section in Springfield, Mass., on May 17, R. E. Northway, president of the Northway Motors Corporation, described types of spring-suspension for automobiles and discussed the materials available and the treatment found satisfactory in producing reliable springs.

The designing of a set of springs that will be satisfactory has always been more a matter of good judgment and experience than calculation. There are so many unknown quantities in the bringing out of a new model that the best of engineers have found it advisable, after making their calculations, to consult practical spring-makers and have several sample sets made up and tried out under varying loads and road conditions before approving the design.

During the past 25 years, the automobile industry has tried out not only every type of spring-construction and suspension existing previous to the advent of the automobile, but also many new types that have been designed during this period. Many auxiliary devices have also been designed to assist or control the action of springs. Some of these devices are really good and do help to overcome the faults of poor spring design and construction; but to insure good riding qualities, long life and good performance on the road, springs must be designed properly and constructed of suitable material that has been properly worked from the blast furnace to the finished spring.

Only Leaf Spring Stands Test of Time

The laminated or leaf spring in its various forms is the only type that has stood the test of time. In the early days of automobile development, many types of coil spring were tried out, some arranged to carry the load in suspension, some in compression. These were soon discarded, however, for it was found that they were as expensive as leaf springs and required a dash-pot or restricted air-control device to be satisfactory.

The prevailing types of leaf springs are the quarter-elliptic, half-elliptic, three-quarter-elliptic and full elliptic. The three-quarter plate form was used up to 1910 or 1911, but is not in use today, and the full-plate form is practically impossible to use. The full-elliptic spring, when properly designed and suspended, gives excellent riding qualities, but it has been practically discarded, although one of the oldest automobile companies in the United States, with a car known for its good riding qualities, has always used it.

Today the quarter and the half-elliptic in their various forms of suspension are the popular types of spring. A study of the cars using them shows that the quarter-elliptic is almost exclusively confined to the low-priced car. When properly designed and constructed, there is no doubt that this type will give excellent riding qualities at a low manufacturing cost. For heavy-duty high-grade cars, on the other hand, there is no doubt of the popularity of the half elliptic. Of the 109 companies listed as exhibitors at the New York City show this year, 85, or 78 per cent, were using half-elliptic springs suspended in the conventional manner, 2 or approximately 2 per cent, were listed as using the quarter elliptic and the remaining 20 per cent were divided among the other types.

It is Mr. Northway's opinion that the cantilever type of suspension, quarter-elliptic cantilever, half-elliptic cantilever and double quarter-elliptic cantilever is at a standstill. Of course every type of suspension has its advocates, but a careful study of manufacturing costs and operation on the road, indicates that the standard half-elliptic spring, fastened to the axle approximately in its center, bolted to the frame at its front end and shackled to the frame at the rear end, is the most economical to manufacture and can be made to have all the good riding qualities of any of the other types of suspension without dangerous side-sway at high speeds.

Usually it is necessary to have an entirely different set of springs for a closed car, and sometimes it is advisable to make a slightly different spring for the right front spring, on account of a heavy engine-torque.

Fundamentals of Spring Design

In summing up the fundamental principles of spring design, Mr. Northway listed these as essential:

(1) A long spring is more flexible and easier riding than a short one

(2) A spring should carry its normal load without much camber, that is with the main leaf practically straight.

(3) The maximum safe deflection is dependent on the thickness of the main leaf and the elastic-limit of the material used.

(4) A spring made of thick leaves will be stiffer than one made of thin leaves, although both carry the same load

When the question of what material is to be used has to be decided, many things have to be taken into consideration. The terms carbon steel, vanadium steel, silico-manganese steel, chrome vanadium and many registered trade names are meaningless unless coupled with the reputation of the steel-maker and the spring-maker for uniformity of material and workmanship.

An alloy-steel having a fine chemical analysis in spots but lacking uniformity will never make a good spring. A steel that shows a good uniform chemical analysis can be spoiled in working or heat-treating. An alloy-steel improperly handled will not make as good a spring as a high-grade carbon-steel formed and heat-treated correctly. Therefore, to produce good springs it is not only necessary to select good materials and have a good design, but it is absolutely essential to select a good spring-maker to look after the details.

Mr. Northway closed his talk with a detailed description of the old guess-work way of spring-making, as contrasted with the carefully controlled modern methods.

In the discussion that followed, a number of new points were developed. In answer to a question put by Mr. Abell, Mr. Northway said that for easy riding it is advisable to keep the rate of vibration of a spring below 90 per min. He could not, however, say whether it was well to reduce it to 50, the rate of vibration of an English spring about which Mr. Abell had inquired.

Asked whether there was a different ratio between the front and the rear springs, Mr. Northway answered that, although it is necessary to adapt the method to the individual model, he had sometimes found it necessary to make a stiffer front spring, to hold the machine in the road. A shorter front spring is needed for the same reason.

The Department of Commerce film, the Story of Alloy-Steel, followed Mr. Northway's talk.

The officers of the New England Section for the coming year will be: Chairman: R. E. Northway; Vice-Chairman: E. O. Sutton; Secretary: V. A. Nielsen; Treasurer: Linwood H. Young. Mr. Nielsen will be the New England delegate on the 1924 National Nominating Committee.

OBITUARY

H. S. McDewell, research engineer for the Maxwell Motor Co., Detroit, Mich., died suddenly at his residence in the City of Washington, April 6, 1923, aged 37 years. He was born at Winthrop, Mass., July 9, 1885. After graduating from Phillips Exeter Academy, he entered Harvard University in 1903 and was graduated with the class of 1907 from the mechanical-engineering course in the Lawrence Scientific School. In 1908, upon completion of post-graduate work in internal-combustion engineering at the Graduate School of Applied Science, of Harvard, he received the degree of Master of Mechanical Engineering.

His professional career began in 1908 with the Allis-Chalmers Mfg. Co., Milwaukee, where he became gas-engine erecting-engineer, and was employed in erecting, supervising and redesigning large stationary gas engines of 300 to 6000 b.hp. until 1914. From 1914 to 1917 he was an instructor in internal-combustion engineering and laboratory practice and participated in research work at the University of Illinois. He then became engineer of tests in the aeronautical engine-testing laboratory at the Washington Navy Yard and supervised the testing and development of aeronautical engines and powerplant accessories for a period of about 5 years. Subsequently, his connection was with the Maxwell Motor Co., as stated. He was especially competent in the design, construction and development of large stationary gas engines and gas producers, and of aeronautical engines.

Mr. McDewell collaborated with Prof. L. S. Marks in the authorship of Gas and Oil Engines and Gas Producers, published in an encyclopedia of engineering of the American Technical Society, Chicago, and later included in Bulletin No. 3 issued by the Naval Consulting Board. He also collaborated in preparing the manuscript for the internal-combustion section of the mechanical engineer's handbook issued by the McGraw-Hill Book Co. He was a charter life member of the Association of Harvard Engineers and a member of the American Society of Mechanical Engineers, having been elected in 1908.

He was elected to Service Member grade in the Society April 12, 1919, and was transferred to Member grade, Jan. 9, 1923. Mr. McDowell is survived by his widow and two children, his mother and a brother.

Applicants *for* Membership

The applications for membership received between April 15, and May 15, 1923, are given below. The members of of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ASHLEY, RAYMOND T., president and manager, Ashley Patents, Inc., *Reno, Nev.*

BAER, W. D., secretary and treasurer, Iron City Spring Co., *Pittsburgh.*

BAKER, B. F., designer, Rock Island Arsenal, *Rock Island, Ill.*

BEELER, WILLIAM R., student, University of Michigan, *Ann Arbor, Mich.*

BLEYLE, C. A., supervisor, Texas Co., *Boston.*

BOSE, SUDHER, student, Cleveland School of Technology, *Cleveland.*

BOULDEN, H. T., vice-president, Selden Truck Corporation, *Rochester, N. Y.*

COCHRANE, R. A., mechanic, Motor Transit Co., *Los Angeles.*

COLLEY, P. F., experimental engineer, Yellow Cab Mfg. Co., *Chicago.*

COLLINS, J. F., chief engineer, Mitten Traylor, Inc., *Philadelphia.*

COURTRIGHT, B. F., chief chemist and metallurgist, Wisconsin Steel Co., *Chicago.*

CUSTER, LEVITT LUZERN, president and treasurer, Custer Specialty Co., *Dayton, Ohio.*

DONALDSON, W. R., designer, General Motor Truck Co., *Pontiac, Mich.*

DUMAS, PAUL L., editor of readers clearing house, *Motor Age, Chicago.*

DURHAM, CADY B., assistant general manager, Buick Motor Co., *Flint, Mich.*

EDINGER, EDWARD PETER, student engineer, Franklin Automobile Co., *Syracuse, N. Y.*

GRAY, JOHN S., student, University of Utah, *Salt Lake City, Utah.*

GREY, EDWARD, service manager, 1055 Virginia Avenue, *New York City.*

GREY, EUGENE K., general superintendent of motor equipment, Gulf Refining Co., *Pittsburgh.*

HALL, H. R., assistant to general service manager, New York Yellow Cab Sales Co., Inc., *New York City.*

HANFORD, H. W., student, Iowa State College, *Ames, Iowa.*

HARRINGTON, H. R., assistant engineer, Ruggles Motor Truck Co., *Saginaw, Mich.*

HAYDEN, URBAN, mechanic, 584 Chetwood Street, *Oakland, Cal.*

HESS, FRANK J., assistant automotive engineer, Tide Water Oil Co., *Bayonne, N. J.*

HOELER, WILLIAM, manager and superintendent of body shop, International Motor Co., *New York City.*

IRGENS, FINN TRUMPY, student, Purdue University, *Lafayette, Ind.*

JUDD, IRVING H., chief draftsman, Whitehead & Kales Co., *River Rouge, Mich.*

KAWST, J. KAUFMAN, engineer-mechanic, 116 West 77th Street, *New York City.*

KELLEHER, R. J., European representative, North East Electric Co., *Paris, France.*

KENT, FRANK J., patent lawyer, Cox, Kent & Campbell, *New York City.*

KNIGHT, B. W., sales manager, Ensign Carburetor Co., *Los Angeles.*

LANDSTADT, HANS, works manager, Morris Motors, Ltd., *Oxford, England.*

LANE, F. J., salesman, Allyne-Zerk Co., *Cleveland.*

LEMON, BURTON J., technical service department, United States Tire Co., *New York City.*

LEONHARDT, HARRY H., salesman of automotive parts and mechanic, Gorey Automotive Parts Co., *New York City.*

LEWIS, JOSEPH CARLETON, service manager, Noyes Buick Co., *Boston.*

LINDEMAN, EDWARD H., sales engineer, Perfection Spring Co., *Cleveland.*

MCCARTHY, J. LUCIEN, automobile mechanic, 576 Green Street, *Cambridge, Mass.*

MCKELVY, TOM M., inventor and designer, McKelvy Rotary Valve Co., *Fresno, Cal.*

MATHEWSON, M. I., experimental and designing engineer, Detroit Gear & Machine Co., *Detroit.*

MELDRIM, H. W., student, Carnegie Institute of Technology, *Pittsburgh.*

MEYER, FRED C., stock clerk, Uppercu-Cadillac Motor Car Co., *New York City.*

MICHELIN, MARCEL, Michelin & Cie., *Clermont-Ferrand, France.*

MONJAR, J. G., sales representative, Hyatt Roller Bearing Co., *Detroit.*

MUNROE, WILLIAM O., vice-president in charge of manufacturing, Standard Steel & Bearings, Inc., *Philadelphia.*

O'HAIRE, P. J., foreman machinist, Harrolds Motor Car Co., *Long Island City, N. Y.*

O'HARE, G. DENNIS, research engineer, O'Hara & Smith, *San Francisco.*

PATTERSON, C. W., lubricating engineer, Standard Oil Co. of Louisiana, *Memphis Tenn.*

PILE, W. D., automobile engineer, Clanwilliam Motor Co., *Dublin, Ireland.*

RANDOLPH, DONALD W., assistant mechanical engineer, Bureau of Standards, *City of Washington.*

RASCH, HOWARD A., student, University of Michigan, *Ann Arbor, Mich.*

RIES, BENJAMIN A., chief engineer, Edward R. Bacon Co., *San Francisco.*

RUMELY, V. P., car superintendent, Hudson Motor Car Co., *Detroit.*

SAUNDERS, L. P., experimental engineer, Harrison Radiator Corporation, *Detroit.*

SCHELL, CARL A., engineer, Thermoid Rubber Co., *Cleveland.*

SHARLOCK, HERBERT L., vice-president, Gernandt Motor Corporation, *South Bend, Ind.*

SHIMIZU, YUTARO, New York representative, Yanese Automobile Co., *Tokyo, Japan.*

SMALLEY, J. SHEPARD, chief engineer, A. Meister Sons Co., *Sacramento, Cal.*

SMITH, GEORGE L., designing engineer, 2614 Woodley Place, *City of Washington.*

SPOFFORD, HARRY H. R., mechanical engineer, Copper & Brass Research Association, *New York City.*

STADER, GEORGE D., manager, Ryan Bros., *Chicago.*

STEELE, FLOYD HARRY, factory manager, Handy Governor Corporation, *Detroit.*

STOLL, ALFRED E., student, University of Michigan, *Ann Arbor, Mich.*

SWANTESON, CARL A., service manager, T. V. T. Motors Corporation, *City of Washington.*

THOMSON, HORACE L., research engineer, *Leland, Mich.*

VANATTA, JEAN K., mechanical engineer, Mudge & Co., *Chicago.*

WALLER, EINAR, designing engineer, General Motors Corporation, *Detroit.*

WEADICK, ROBERT M., student, Franklin Institute, *Boston.*

WETHERBY, W. G., secretary and treasurer, Handy Governor Corporation, *Detroit, Mich.*

WOOD, WILLIAM G., JR., sales engineer, I. Silver, *Brooklyn, N. Y.*

WOOD, WALTER G., student, University of Utah, *Salt Lake City, Utah.*

YACKEY, GEORGE FREDERICK, student, University of Illinois, *Urbana, Ill.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between April 10 and May 10, 1923. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

ALMEN, J. O. (M) chief engineer, Almen Motors, Inc., *Seattle, Wash.*, (mail) 2349 North Boylston Avenue.

ARATA, L. D. (E S) student, University of Cincinnati, *Cincinnati*, (mail) 1527 Gilpin Avenue.

BELL, JAMES L. (A) general superintendent and assistant to the president, Fulton Motors Corporation, *Farmingdale, N. Y.*, (mail) 20 Front Street.

BENDER, E. J. (A) service engineer, Yellow Cab Mfg. Co., 5901 West Dickens Avenue, *Chicago.*

BLAUMAN, LOUIS W. (A) sales manager, C. M. Grey Mfg. Co., East Orange, N. J., (mail) 176 Grafton Avenue, *Newark, N. J.*

BLOSSOM, ROY E. (A) special sales representative, Prest-O-Lite Co., Inc., *Indianapolis.*

BOYD, PAUL M. (E S) student, University of Minnesota, Minneapolis, (mail) 1408 Albany Street, *St. Paul, Minn.*

BROWN, NELSON TURNER (M) superintendent, Philadelphia Rapid Transit Co., *Philadelphia*, (mail) 5415 North Sixth Street.

BUCHANAN, ALEXANDER D. (E S) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 1038 East Huron Street.

BUNNELL, FRED H. (E S) student, Michigan Agricultural College, *East Lansing, Mich.*, (mail) P. O. Box 1014.

CAMPBELL, FRED J. (M) chief draftsman, Falls Motors Corporation, *Sheboygan Falls, Wis.*

CAMPBELL, J. GORDON (A) foreman, Willys-Overland, Ltd., *Toronto, Ont., Can.*, (mail) 1403 Bloor Street, West.

COLLINS, P. A. (A) technical service, Reo Motor Car Co., *Lansing, Mich.*

CONNELLY, FRANK HAROLD (E S) student, Tri-State College of Engineering, Angola, Ind., (mail) *Ashville, N. Y.*

DAILEY, J. B. (M) chief metallurgist, General Motors Corporation, Detroit, (mail) 131 Porter Street, *Dearborn, Mich.*

DAUGHERTY, R. E. (M) designer, Goodyear Tire & Rubber Co., Goodyear Heights, Akron, Ohio, (mail) 200 Trenton Avenue, *Findlay, Ohio.*

DAVIS, ARTHUR J. (E S) student, Michigan Agricultural College, *East Lansing, Mich.*

DAY, AUSTIN WESLEY (E S) student, University of Cincinnati, *Cincinnati*, (mail) 2617 University Court.

DODS, JOHN P. (A) vice-president, Brightman Mfg. Co., *Columbus, Ohio.*

DURHAM, PERCY J. (M) president and general manager, P. J. Durham Co., 244 West 49th Street, *New York City.*

DWIGANS, ROGER W. (E S) student, University of Cincinnati, *Cincinnati*, (mail) 359 Ludlow Avenue.

DWYER, C. EUSTACE (M) sales engineer, Timken-Detroit Axle Co., *Detroit*, (mail) University Club.

EVANS, BOYD V. (M) chief engineer, Detroit Motorbus Co., *Detroit*, (mail) 1586 Montclair Avenue.

FAIRFIELD, JOHN GUTHRIE (M) assistant professor of mechanical engineering, Rensselaer Polytechnic Institute, *Troy, N. Y.*

FAY, CHARLES R. (J) production supervisor, Weidely Motors Co., *Indianapolis*, (mail) 4206 Cornelius Avenue.

FERRIS, WALTER (M) chief engineer, Oilgear Co., 60 27th Street, *Milwaukee.*

FISHLEIGH, CLARENCE T. (M) engineer in charge of experimental motor testing, American Car & Foundry Co., *Chicago*, (mail) 4537 North Robey Street.

GIALDINI, B. THOMAS (E S) student, University of Cincinnati, *Cincinnati*, (mail) 70 Ehrman Avenue.

GLYNN, FREDERICK K. (M) engineer of motor vehicles, New York Telephone Co., New York City, (mail) 492 Bedford Avenue, *Brooklyn, N. Y.*

GODBOLD, E. J. (A) Climax Engineering Co., Clinton, Iowa, (mail) 1245 12th Avenue, *Moline, Ill.*

GREENE, WHITNEY E. (J) instructor, Pennsylvania State College, *State College, Pa.*, (mail) University Club.

HANFORD, L. T. (A) general sales manager, Paige-Detroit Co. of N. Y., 529 West 55th Street, *New York City.*

HARTSHORN, STANLEY D. (E S) International Motor Co., *New Brunswick, N. J.*

HENRY, HOWARD W. (M) chief engineer, Klaxon Co., Newark, N. J., (mail) 264 Franklin Street, *Bloomfield, N. J.*

HIGGINS, WILLIAM H. C., JR. (M) chief engineer, Advance-Rumely Co., *La Porte, Ind.*, (mail) 1033 Indiana Avenue.

HODTUM, CLARENCE (E S) student, University of Cincinnati, *Cincinnati*, (mail) 3112 Borrman Avenue.

HOLMES, GEORGE ARTHUR (E S) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 1115 White Street.

HUBNER, WILLIAM HALLER (E S) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 1107 Prospect Street.

IRISH, L. A. (A) manager, New York Yellow Cab Co., Sales Agency, Inc., *New York City*, (mail) 614 West 131st Street.

JORDAN, EDWARD S. (A) president, Jordan Motor Car Co., Inc., 1070 East 152nd St., *Cleveland.*

JUDSON, ARTHUR (A) vice-president, Fuller & Smith, Bulkley Building, *Cleveland.*

KING, W. GRANT (M) president, King Sewing Machine Co., *Buffalo.*

KOOLHOVEN, FREDERICK (F M) N. V. Nationale Vliegting Industrie, Prinsessegracht 21, *The Hague, Holland.*

LAKE, BURTON G. (J) U. S. S. S-23, c/o New London Ship & Engine Co., *Groton, Conn.*

LAUGHLIN, T. F. (A) field service representative, San Francisco and Salt Lake districts, Studebaker Corporation of America, Detroit, (mail) 1625 Van Ness Avenue, *San Francisco.*

LUCKETT, DINWIDDIE J. (S M) ordnance engineer, design section, Ordnance Department, Rock Island Arsenal, Ill., (mail) 712 East 14th Street, *Davenport, Iowa.*

LYNCH, W. ROSWELL (A) sales engineer, Gray & Davis, Inc., Boston, Mass., (mail) 503 West Eighth Street, *Connersville, Ind.*

MCALLISTER, RALPH HAMMOND (J) student, University of Illinois, *Urbana, Ill.*, (mail) 707 Gregory Place.

MCARDLE, J. P. (A) retail salesman, G. M. C. Truck Co., *Chicago*, (mail) 5343 Ellis Avenue.

MCVEIGH, LUKE M. (E S) student, Cornell University, *Ithaca, N. Y.*, (mail) 132 Blair Street.

MAGNUSON, ROY M. (J) draftsman, Holt Mfg. Co., *Stockton, Cal.*, (mail) 135 East Lindsay Street.

MARKEY, ROSCOE I. (S M) aeronautical designer, engineering division, Air Service, McCook Field, Dayton, Ohio, (mail) R. F. D. No. 9, Box No. 30, *West Alexandria, Ohio.*

MARSHALL, A. F. (M) experimental engineer, R & V Motor Co., *East Moline, Ill.*, (mail) 2016 Eighth Street.

MEIGS, DWIGHT R. (A) vice-president, U. S. Axle Co., *Pottstown, Pa.*

MORRISH, NEIL B. (E S) student, Michigan Agricultural College, *East Lansing, Mich.*, (mail) 1 B Wells Hall.

MRAZ, EMIL (A) superintendent, Temme Spring Corporation, Chicago, (mail) 8100 Malvern Avenue, *Detroit.*

OSTBY, OSCAR F. (A) general sales manager, Prest-O-Lite Co., Inc., *Indianapolis*, (mail) Spink Arms Hotel.

PIERSON, D. M. (M) assistant experimental engineer, Dodge Bros., *Detroit*, (mail) 6240 Necla Avenue.

RAGSDALE, E. J. W. (M) Edward G. Budd Mfg. Co., Hunting Park Avenue, *Philadelphia.*

RALPH, HORACE F. (E S) student, University of Utah, *Salt Lake City, Utah*, (mail) 3396 South Ninth Street.

ROBERTSON, JAMES F. (A) general manager, Defiance Motor Truck Co., *Defiance, Ohio*, (mail) 704 Clinton Street.

ROSS, WALTER D. (J) student, Purdue University, *West LaFayette, Ind.*, (mail) Box 101.

SCHIMELFENIG, MAJOR, C. A. (S M) Chief of the maintenance division, Ordnance Department, *City of Washington*, (mail) Army and Navy Club.

SCHWEITZER, PAUL H. (A) mechanical engineer and tool designer, Oakland Motor Car Co., *Pontiac, Mich.*, (mail) 382 Oakland Avenue.

SHELLER, GEORGE A. (A) service manager, William Parkinson Motor Sales Co., 622 West 57th Street, *New York City.*

SHORT, BLADEN M. (A) sales manager, C. G. Spring Co., *Detroit,* (mail) 5983 Woodward Avenue.

SLAKER, CHARLES S. (A) general manager, Hayes Wheel Co., Jackson, Mich., (mail) 422 North Meridian Street, *Indianapolis.*

SOLT, VIVIAN M. (J) builder of racing cars and student, Solt Motors, 1805 Leavenworth Street, *Manhattan, Kan.*

SPARKS, CLIFFORD M. (A) sales engineer, Sparks-Withington Co., *Jackson, Mich.,* (mail) 202 Edward Avenue.

STOWE, GEORGE (A) vice-president and general manager, Reo Motor Car Co., *New York City,* (mail) 884 Riverside Drive.

TAYLOR, WILLIAM WHITWORTH (E S) student, University of Cincinnati, *Cincinnati,* (mail) 3442 Brokline Avenue.

TELFORD, MARSHALL H. (E S) student, Tri-State College, *Angola, Ind.,* (mail) 114 South Woodard Street.

THIERSCH, WALTER (E S) student University of Cincinnati, *Cincinnati,* (mail) 4261 Fergus Street.

TRANSCONTINENTAL OIL CO. (Aff) Benedum-Trees Building, *Pittsburgh.*

Representatives:

Gray, Crosby, acting general manager of retail sales.
Johnson, H. M., lubrication engineer.
Robinson, O. D., vice-president.

TROUANT, VIRGIL E. (J) engineer, automotive engineering department, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

VOLK, ALBERT (J) engineer, aircraft department, G. Elias & Bros., *Buffalo,* (mail) 118 Herkimer Street.

WAITE, GORDON TARBELL (E S) student in mechanical and aeronautical engineering, University of Michigan, *Ann Arbor, Mich.,* (mail) 1617 Washtenaw Avenue.

WARFORD, HENRY W. (J) student, Tri-State College, *Angola, Ind.,* (mail) 403 East Broad Street.

WARREN, KENNETH WILLIAMS (E S) student, Stevens Institute of Technology, Hoboken, N. J., (mail) 131 DeMott Avenue, *Clifton, N. J.*

WEISEL, WILLIS L. (E S) student, University of Cincinnati, *Cincinnati,* (mail) 28 Lakewood Avenue.

WELSH, JAMES W. (M) executive secretary, American Electric Railway Association, 8 West 40th Street, *New York City.*

WILLIAMS, S. M. (A) manager, Autocar Sales & Service Co., Ardmore, Pa., (mail) 553 West 23rd Street, *New York City.*

WILSON, HARLAND D. (M) chief chemist and chemical engineer, Prest-O-Lite Co., Inc., *Indianapolis.*

WRIGHT, J. R. (M) research engineer, development department, Standard Oil Co. of New Jersey, P. O. Box 276, *Elizabeth, N. J.*

ZEDER, JAMES C. (J) layout work, Timken Roller Bearing Co., *Canton, Ohio,* (mail) 1011 Fulton Road, N. W.

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

INDEX TO VOLUME XII, JANUARY-JUNE, 1923

PAGES

January 1-136
February 137-254
March 255-322
April 323-410
May 411-514
June 515-632

A

Abrasive qualities of steels 76
Accomplishment of American automotive engineers in fuel economy 311

Addresses

Banham, W J L 498
Binkerd, Robert S 499
Bradfute, O E 501
Hasson, J O 504
Jordan, E S 308
Lee, Elisha, at annual dinner 151
Of members wanted 292
Presidential of B B Bachman 167
Swayne, Alfred H 498
Advantages of natural-gasoline blends 275
Advisory Board on highway research 294
Aeronautic session at annual meeting 237

Aeronautic Division, S A E

Activities 561
Personnel 189, 509

Aeronautics

Navy airship inspected 131
Terrain for glider contests 275

Agricultural Power Equipment Division, S A E

Activities 404, 561
Personnel 189, 565
Report of semi-annual meeting 565
Air and water-cooled type comparisons 51
Air-cleaners for tractor engines, test of 376
Air-cooled cylinder layout 31
Air-cooled cylinders, foundry production of 53
Air-cooled versus water-cooled engine 332
Aircraft-engine practice as applied to air-cooled passenger-car engines (S D Heron) 31

Aircraft

Air-cooled versus water-cooled engines 332
Former and present engine tests 326
Influence of powerplant weight on transportation costs 334
Progress made in engine development 326
Recent developments in engines in the Navy 325

Air Mail Service

Effect on the airplane designer 264
What it has demonstrated 263

Airplanes

Cross-licensing 298
Design of commercial 155, 363
Economy of design 156
Effect of the designer of mail service 264
Elimination of noise 158
Fundamental principles of design of military 614
Government's peacetime problem 297
Immediate possibilities of commercial service 263, 359
Military development and construction in peacetime 296, 361
Old designs and slow delivery 297
Safety 157
Size 156
Speed and comfort 158
Air supply 42
Alloys, copper-rich bearing 615

Aluminum

Casting alloy cylinder-heads 55
Gating for alloy casting 56
American farmers, 1922 returns to 544
Amplification of the Army study 430
Angular position of knuckle-pivots 381

Annual Meeting, S A E

Aeronautic session 237
Body engineering session 247
Detonation session 239
Detroit in 1924 243
Dinner 250
Dinner broadcasted 245
Engine-cooling session 242
Fuel session 238
Meetings Committee report 232
Membership Committee report 231
Program 130
Radio broadcast of dinner speeches 131
Railroad fares reduced 131
Report of 231
Research session 241
Sections Committee report 233
Treasurer's report 10, 232
Annual report of treasurer 10
Apparatus and procedure for gaseous detonation experiment 370
Arms, tie-rods and tie-rod 388
Army plan, development of 426
Army plan of highway transport 421
Australia, S A E in 489
Automobile fatalities 534
Automobile finishing-varnish (L V Pulsifer) 89, 335, 456

Automobiles

Across the Sahara Desert by 502
Advance toward simplified body construction 213
Advantages of fabric-covered body 216
Aircraft-engine practice as applied to air-cooled engines 31
Axis of oscillation 314
Causes of poor service 193
Changes in body construction 213
Cheaper closed-body construction 213, 450
Closed-body quantity-production 177
Closed-car demand increasing 85
Cooling capacity of radiators 57
Development constituents 87
Development of a modern service-system 193, 539
Developments and prophecies 177
Drivers' comments on test 7
Economic fuel volatility 139
Experience notes from a production notebook 22
Factory inspections 206
Fatalities 534
Field conditions 205
Finishing-varnish 89, 335, 456
Follow-up on repair-jobs 203
Gasoline mileage 5
Good service as a sales asset 193
New attitude toward service 193
Notes on spring action 312
Painting practice from the chemist's viewpoint 335
Periods of vibration 312
Practical considerations in body construction 215
Resale value of 10
Service and its relation to the industry 265, 535
Some unique features of production 25
Stock-department supervision 205
Taxation on a tire consumption basis 61
Test 140
Tested 3
Testing leather substitutes and top materials 276, 449
24-hr. service on Ford 265
Unconventional type of body 214
Weight distribution 314
Wheel-wabble 384

Automotive Industry

Cost considerations 88
Maintenance effects of electrical-equipment standardization 538
Petroleum and automotive engineers discuss common problems 118
Problems in front of the engineer 86
Service cooperation between manufacturer and dealer 205
Training mechanics 99
Transfer of energy 86
Work as a "profession" 17
Automotive-service cooperation between manufacturer and dealer (J F Page) 205
Automotive transportation by trailers (E R Greer) 19
Automotive transportation development 468

Automotive Transportation Meeting, S A E

Announced 244, 306
Dinner 497
Papers for 306
Program 399
Report of 490
Automotive vehicle insurance 596

Automotive Vehicles

Critical study of modern steering-systems 377
Insurance 596
Automotive work as a "profession" (Dr C A Prosser) 17

Aviation

Dangers of flight 342
Development of the Hannover sailplane 77
Inducing the public to fly 351
Influencing the public 351
International Air Congress 353
Passenger-carrying flying-boat operation 351
Safety and comfort as inducements to travel 342
Axis of oscillation 314

Axle and Wheels Division, S A E

Accepted recommendations 218
Activities 124, 315, 316, 404, 486, 561
Personnel 189, 262, 566
Report at annual meeting 219, 229
Report at semi-annual meeting 566

Axles

Changes in condition 534
Class-B Army 530
Investigation of some heavy-duty truck drive 517
Lubricant 523
Possibilities of improvement in efficiency 529
Results of tests 523
Selection of *B* 534
Test methods and equipment 520
Test procedure 521
Test program 522
Wheels and 595

B

Bachman, B B, presidential address 167
Balance, new principles in rotative 562

Ball and Roller Bearings Division, S A E

Activities 124, 127, 404, 561
Personnel 189, 509, 566
Report at semi-annual meeting 566
Unaccepted recommendations 225
Banham, W J L, address 498
BARNARD, DANIEL P, ON FURTHER DATA ON THE EFFECTIVE VOLATILITY OF MOTOR FUELS 287
Bars, determining the magnetic properties of short 209
BAYER, L F, ON PROPER UTILIZATION OF NATURAL GASOLINE 273
Belt speeds 588
Benzene as engine fuel 187
BERSIE, HUGH G, ON TAXICAB-BODY CONSTRUCTION 480
BESSON, MAJOR F S, ON HIGHWAYS AND TRAFFIC IN A CITY 612
BINGHAM, DR W V, ON STANDARDIZED MENTAL TEST IN PERSONNEL SELECTION 272
Binkerd, Robert S, address 499
Biplane and monoplane comparison 84
BJORNBERG, S O, ON HOW TO USE GEAR-CUTTING HOBS 181
Blast direction 42
Blended fuels 274
BLYTHE, R R, ON SAFETY AND COMFORT AS INDUCEMENTS TO AIR TRAVEL 342

Bodies

Actual advantages of fabric covered 216
Advance toward simplified construction 213
Changes in construction 213
Cheaper closed construction 213
Demountable "flats" 444
Frame stiffness and structure 596
Methods of joining frame members 481
Practical considerations in construction of 215
Taxicab construction 480
Unconventional type of 214
Woods suitable for taxicab framework 481
Body engineering session at annual meeting 247
Bradfute, O E, address 501
Brakes, four-wheel 611
BRAUTIGAM, H H, ON 1922 AND THE MOTORBOAT INDUSTRY 302

BRODIE, J, ON EXPERIENCE NOTES FROM A PRODUCTION NOTEBOOK 22
BRUNO, H A, ON PASSENGER-CARRYING FLYING-BOAT OPERATION 351
Burton process of cracking 510
Business outlook 176

C

Camshafts, valve-gear arrangement and 38
Carbon dioxide, effect of inert 319

Carbureters

Commercial metering characteristics 74
Requirements 73

Carburetion

Experimental survey of gasoline and kerosene 63, 460
Gasoline 66
CARLSON, R E, ON ECONOMIC MOTOR-FUEL VOLATILITY 139
Cartage-practice a standard for our railway-terminal trucking, English 437

Cartage

Control system 440
Costs and tonnage hauled 444
Delay and excessive cost 439
English practice a standard for our railway-terminal trucking 437
English railway system 439
Opinions regarding the English system 445
Unified control of 444
Castering or trailing effect 382
Casting aluminum-alloy cylinder-heads 55

Castings

Aluminum-alloy cylinder-head 55
Gating for aluminum-alloy 56
Causes of poor service 193
Cement, record production of Portland 472
Central committee on lumber standards 98

Chain Division, S A E

Accepted recommendations 218
Activities 561
Personnel 189
Report at annual meeting 219
Changes in axle condition 534
Changing aspect of transportation 447
Characteristics of a satisfactory signal 476
Charges, flat-rate system for service 194
CHASE, HERBERT, ON CRITICAL STUDY OF MODERN AUTOMOTIVE-VEHICLE STEERING-SYSTEMS 377
Chassis, tractor 594
Cheaper closed-body construction (George J Mercer) 213, 450
Chemist's viewpoint, painting practice from the 335

Chicago Service Meeting, S A E

Announced 132
Discussion of papers 535
Report 307
Technical sessions 307
Chronicle and comment 1, 137, 255, 323, 411, 515
CITROËN, ANDRÉ, ON CROSSING THE SAHARA DESERT BY AUTOMOBILE 502
Class-B Army axles 530
Closed-car demand increasing 85
Clutch, marine engine 260
Coat-finishing exhaust manifolds 21
COLEMAN, C T, ON MOTOR-TRANSPORT PERFORMANCE WITH VARIED FUEL VOLATILITY 343
Comfort and safety as inducements to air travel 342
Commerce Department meeting 365
Commercial carbureter metering characteristics 74
Commercial organization under the Army plan 428

Committees

Administrative, S A E, personnel 178
Personnel of Standards 189
Simplification Conference 365
Standards meeting 217
Comparison of cooling capacity of radiators 59
Comparison of steering-gear types 386
Compression, internal-combustion engine characteristics under high 111, 354
Connection of the Research Committee with fuel research (H M Crane) 207
Consciousness, professional 17
Constitution Committee, S A E, personnel 178
Construction of plywood roof 483
Consumers' prices, spread in producers' and 596
Control charts for service 201
Cooling capacity of automobile radiators (E H Lockwood) 57

Cooling

Capacity charts 60
Exhaust valve 40, 51
Marine engines 257
Surface 36
System for in-line engines 42
Coordination of the motorbus and the street railway (C D Emmons) 433
Copper-rich bearing alloys (C L Landon) 615

Costs

Cartage and tonnage hauled 444
Considerations 88
Delay and excessive cartage 439
Influence of powerplant weight on transportation 334
Operation of trailers 20
Quality of motor fuel and 310
Research reduces highway 129
Securing data on service 271
Taxicab body 483
Transportation 436

Council Meetings, S A E

December, 1922 18
January, 1923 178
February 262
April 509
Cracking processes in the petroleum industry (Frank A Howard) 510

Cracking

A licensing patent 511
Burton process 510
Facts of the matter 510
Highly developed by Americans 510
Patented methods mostly infringements 511
Processes in petroleum industry 510
CRAIN, H J, ON EXPERIENCE NOTES FROM A PRODUCTION NOTEBOOK 22
CRANE, H M, ON CONNECTION OF THE RESEARCH COMMITTEE WITH FUEL RESEARCH 207
Crankcase oil dilution and oil consumption 7
Crawler type general-purpose tractors 604
Credits, rural 301
Critical study of modern automotive-vehicle steering systems (Herbert Chase) 377
Cultivation obstacles 603
Cultivators, power 600
Current literature, survey of 375
Current standardization work 124, 315, 404
Current work of the Standards Committee 561
Cylinder heads, casting aluminum-alloy 55

Cylinders

Air-cooled layout 31
Cooling surface 36
Design of air-cooled 32
Exhaust-valve cooling 51
Experimental development of air-cooled engine 46
Form of head 33
Foundry production of air-cooled 53
Gating for aluminum-alloy casting 56
Laws governing gaseous detonation 367
Material 34
Performance investigations 47
Performance of air-cooled 32
Performance of multi- 48
Quantity of air 43
Temperature of 38

D

Dangers of flight 342
Dash-boards, types of taxicab 483
Data Sheets, March, 1923, issue 407
DAVIS, J B, ON TESTING LEATHER SUBSTITUTES AND TOP MATERIALS 276, 449
Defects of tractors 593
Delay and excessive cartage cost 439
Demountable "flats" or bodies 444
Department store expense 465
Design of commercial airplanes (E P Warner) 155, 363
Designing motor cars 364
Destructive competition between railways and motorbuses 436
Detailed consideration of three-dimensional indicator-card surfaces 106
Determining the magnetic properties of short bars 209
Detonation 70
Detonation session at annual meeting 239

Detonation

Apparatus and procedure for experiment 370
Application of gaseous to internal-combustion engines 369
Laws governing gaseous 367, 458
Representation of, by pressure-volume-quantity indicator-card 109
Development of a modern service-system (Don T Hastings) 193, 539
Development of Army plan 426
Development of the Hannover sailplane (Georg H Madelung) 77
Dilution, crankcase-oil tests 144

Dinners

Annual 250
Automotive transportation 497
Distance of haul and economy of operation 471
Double-reflector type of head-lamp (Bruno Heymann) 100
Drag-link location 385
Drivers' comments 7
Drivers of automobiles tested 4
Driver's responsibility for fuel waste 311
DRUMMOND, R S, ON GEAR GRINDING 173
Drying and safety of working tests of varnish 92
DUESENBERG, F S, ON ENGINEERING INFORMATION FROM THE RACE TRACK 616
DUNK, WILLIAM, ON SOME UNIQUE FEATURES OF AUTOMOBILE PRODUCTION 25

E

EASON, C M, ON GENERAL-PURPOSE FARM TRACTOR 597
Economic motor-fuel volatility (R E Carlson) 139
Economy, airplane design for 156
EDGAR, JOHN, ON HOBBING-MACHINE OPERATION 179
Education of engineers 286
Effect of inert carbon dioxide 319
Effect of interior finish 319
Effect of load 70

Efficiency

Possibilities of improving axle 529
Tractive 588

Electric Vehicle Division, S A E

Accepted recommendations 218
Activities 404, 405, 561
Personnel 190, 571
Report at annual meeting 220
Report at semi-annual meeting 571
Subjects assigned 18

Electrical Equipment Division, S A E

Accepted recommendations 218
Activities 404, 561
Personnel 190, 568
Report at annual meeting 220
Report at semi-annual meeting 568
Electrical-equipment standardization, maintenance effects of automotive 283, 538
Electrical resistance, importance of a minimum 479
Elimination of noise in airplanes 158
EMMONS, C D, ON COORDINATION OF THE MOTORBUS AND THE STREET RAILWAY 433
Energy, transfer of 86
Engine-cooling session at annual meeting 242

Engine Division, S A E

Accepted recommendations 218
Activities 125, 404, 406, 561
Personnel 190, 573
Report at annual meeting 221
Report at semi-annual meeting 573
Engineer, retailer and the 465

Engineering

Application of principles 465
Stationary internal-combustion developments 304
Problems 473
Two phases of tractor 188
Engineering aspects of traffic (William P Eno) 473
Engineering information from the race track (F S Duesenberg) 616

Engineers

Education of 286
Highway research 294
Relation of automotive to highway 295

Engines

Accessibility of marine 260
Accessories for marine 260
Air and water-cooled type comparisons 51
Air-cooled versus water-cooled 332
Aircraft-engine practice as applied to air-cooled passenger-car 31
Air supply 42
Application of gaseous detonation to internal-combustion 369
Application to the internal-combustion 369
Benzene as fuel 187
Clutch and reverse-gear on marine 260
Coat-finishing exhaust-manifolds 21
Cooling marine 257
Cooling system for in-line 42
Direction of rotation of high-speed marine 261
Effect of load 70
Equipment and apparatus for tests 114
Experimental development of air-cooled cylinders 46
Factors 119
Former and present aircraft tests 326
Fuel-air mixture requirements for 72
Fuel in 310
High-compression performance tests 112
Idling and general operation of marine 259
Influence of powerplant weight on transportation costs 334
Installation requirements of high-speed marine 261
Internal-combustion, application to tractors 598
Internal-combustion characteristics under high compression 111, 354
Laws governing gaseous detonation 367
Low-temperature operation 119
Lubrication of high-speed marine 258
Methods of tests 11
New interpretation of exhaust-gas analysis 299
New types 120
Performance and design of air-cooled cylinders 32
Port-arrangement for in-line 37
Pressure-volume-quantity indicator-card 105
Progress made in aircraft development 326
Recent developments in aircraft in the Navy 325
Reduction in weight in aircraft 329
Results of tests 116
Sleeve-valve types 38
Starting marine 258
Tendencies in high-speed marine design 257
Test of air-cleaners for tractor 376
Test procedure 115
Testing fuels for high-compression 11, 358
Tractor 593
English cartage-practice a standard for our railway-terminal trucking (F C Horner) 437
English-railway cartage-system 439
ENO, WILLIAM P, ON ENGINEERING ASPECTS OF TRAFFIC 473
Equilibrium-solution preparation 287
Essentials of signal-system design 476
Evolution 585
Exhaust-gas, new interpretation of analysis 299
Exhaust-valve cooling 40, 51
Experience notes from a production notebook (H J Crain and J Brodie) 22
Experimental development of air-cooled engine-cylinders 46
Experimental survey of gasoline and kerosene carburetion (C S Kegerreis and G A Young) 63, 460
Exports 564

F

Factory car-inspections 206
Fans 45
Farm and urban industries 76
Farm equipment, utilization of existing 606

Farmers

Living-wage for 408
1922 returns to American 544
Fatalities, automobile 534
Fatigue of metals 123
Federal agencies 294
Federal Reserve Banks reserve-ratio 341
Federal road money 122
FENNER, DAVID C, ON OVER-LOADING OF MOTOR TRUCKS 210
Finance Committee, S A E, personnel 178
Finances, S A E 169
Finning, valve location and type of 32

Flat Rates

Limitations of, for service 201
System for service charges 194, 271, 307
Foregather or toe-in of wheels 382
Foundry production of air-cooled cylinders 53
Four-wheel brakes (Malcolm Loughead) 611
Frame stiffness and body structure 596

Frames Division, S A E

Accepted recommendations 218
Activities 404, 561
Personnel 190, 574
Report at semi-annual meeting 574
French test of producer-gas trucks 85
Fuel-consumption tests 140

Fuel Economy

Researches to promote 311
Society's interest in 310
Summary of factors affecting 312

Fuel Problem

Present status 120
Society's research sheds new light on 3
Fuel session at annual meeting 238
Fuel waste, its causes and remedies 310

Fuels

Accomplishment of American automotive engineers in economy 311
Air mixture requirements for engines 72
Average molecular-weight determination 289
Benzene as engine 187
Blended 274
Comparison of gasoline and kerosene 65
Connection of the Research Committee with research 207
Consumption of tractors 592
Consumption tests 140
Continuation of road tests 208
Cost and quality of motor 310
Cylinder 46
Economic motor volatility 139
Effects of volatility investigated 312
Equilibrium-solution preparation 287
Experimental survey of gasoline and kerosene carburetion 63
Further data on the effective volatility of motor 287
In the engine 310
Investigated 289
Limits of accuracy of test 6
Mixture adjustment and waste 311
Motor-transport performance with varied volatility 343
Partial-pressure calculation 289
Proper blends of 274
Researches to promote economy 311
Responsibility of driver 311
Road tests 208
S A E interest in economy 310
S A E research sheds new light on problem 211
Selection for test 3
Summary of factors affecting economy 312
Test 140
Testing for high-compression engines 11
Vapor-pressure measurement 288
Volatility 209
Waste, its causes and remedies 310
Fundamental principles of design of military airplanes (W F Gerhardt) 614
FUNDERBURK, OTIS C, ON SERVICE AND ITS RELATION TO THE INDUSTRY 265, 535
Further data on the effective volatility of motor-fuels (Robert E Wilson and Daniel P Barnard, 4th) 287

G

Gaseous explosions, pressures in 319

Gasoline

Advantages of natural blends 274
Blended fuels 274
Carburetion 66
Comparison of kerosene and 65
Mileage 5
Natural 120
Processes of natural 273
Proper utilization of natural 273
Results of tests 274
Seventh semi-annual survey 397
Specifications 118
Usage of natural 273
Gating for aluminum-alloy casting 56
Gear grinding (R S Drummond) 173
Gear-grinding and tooth-forms (Glenn Muffly) 545
Gear-tooth grinding 547

Gears

Camshaft and valve arrangement 38
Checking dimensions 185
Control of hobs 182
Cost of grinding 174
Grinding 173
Grinding and tooth-forms 545
History of grinding 174
Hobbing-machine operation 179
How to use hobs for cutting 181
Modification of tooth-curves 552
Noise 554
Pitch-diameter 553
Salvaging versus finish-grinding 173
Some causes of tooth errors and their detection 26
Testing grinding accuracy 550
Tooth-form 175
Tooth grinding 547
Tooth spacing 551
Types of machine for grinding 174
Wear 176
General-purpose farm tractor (C M Eason) 597
General-purpose machinery 602
GERHARDT, W F, ON FUNDAMENTAL PRINCIPLES OF DESIGN OF MILITARY AIRPLANES 614
Glider contests, terrain for 275
GOTTSCHALK, V H, ON SOCIETY'S RESEARCH SHEDS NEW LIGHT ON FUEL PROBLEM 3, 211
Grading by "enumerated defects" wrong principle 97
GREER, E R, ON AUTOMOTIVE TRANSPORTATION BY TRAILERS 19

Grinding

Cost of gear 174
Gear 173
History of gear 174
Salvaging versus finish gear 173
Types of machine for gear 174
Group-bonus wage-incentive plan (E Karl Wennerlund) 27
Guarantee or policy work for service 201

H

Hand-work 159
Hannover sailplane, development of the 77
Hardware, types of taxicab 481
Hardwood-lumber needless waste (F F Murray) 95, 455
Hardwood lumber standardization 62

Hardwood

Corrective effort to be applied in safe and sane way of grading 98
Economic reason for high price of 97
Grading by "enumerated defects" wrong principle 97
Great opportunity for simplification of grading 98
Interests of consumer and producer bound together 98
Lumber needless waste 95, 455
Not yet "developed" to provide full utilization value 95
Present grades inadequate, obsolete and wasteful 96
Reason for obsolescence of present grade-basis 96
Hasson, J O, address 504
HASTINGS, DON T, ON DEVELOPMENT OF A MODERN SERVICE-SYSTEM 193, 539
HATT, W K, ON RESEARCH FOUNDATION FOR THE ECONOMIC THEORY OF HIGHWAY IMPROVEMENT 294

Haulage

Distance and economy of operation 471
Successful tractor and semi-trailer railroad-terminal 467
Tremendous volume of tonnage handled 468
HAZELETT, CLARENCE W, ON IMPROVED STORAGE-BATTERY CONSTRUCTION 445

Head-Lamps

Anti-glare 101
Double-reflector type of 100
Glare problem in Europe 100
Glare session at summer meeting 618
Heat-transfer coefficients 58
HERON, S D, ON AIRCRAFT-ENGINE PRACTICE AS APPLIED TO AIR-COOLED PASSENGER-CAR ENGINES 31
HERRMANN, K L, ON SOME CAUSES OF GEAR-TOOTH ERRORS AND THEIR DETECTION 26
HEYMANN, BRUNO, ON DOUBLE-REFLECTOR TYPE OF HEAD-LAMP 100
Highway economics 76
Highway and traffic recommendations 474

Highways and Roads

Advisory Board on Highway Research 294
Army plan of transport 421
Automobile associations and research 294
Automotive engineer and research 294

Building policy 153
Economics 76
Engineer and research 294
Federal agencies and research 294
Federal money 122
Formation of transport centers 429
Military and commercial transport 413
National Automobile Chamber of Commerce and research 294
Research foundation for the economic theory of improvement 294
Research reduces costs 129
Locating engineer and research 294
Testing performance 448
Traffic in a city 612
Traffic recommendations 474
Transportation most important problem 403
Highways and traffic in a city (Major F S Besson) 612
Highways Committee, S A E, personnel 262
Hobbing-machine operation (John Edgar) 179

Hobbing

Machine control 184
Machine operation 179
Operating conditions 180
Process 179

Hobs

Control 182
How to use gear-cutting 181
HOLLOWAY, J H, ON INTERNAL-COMBUSTION ENGINE CHARACTERISTICS UNDER HIGH COMPRESSION 111, 354
HORNER, F C, ON ENGLISH CARTAGE-PRACTICE A STANDARD FOR OUR RAILWAY-TERMINAL TRUCKING 437
Horse transport 442
House Committee, S A E, personnel 178
How to use gear-cutting hobs (S O Bjornberg) 181
HOWARD, FRANK A, ON CRACKING PROCESSES IN THE PETROLEUM INDUSTRY 510
HUEBOTTER, H A, ON INTERNAL-COMBUSTION ENGINE CHARACTERISTICS UNDER HIGH COMPRESSION 111, 354

I

Immediate possibilities of commercial airplane service (C G Peterson) 263, 359
Impact testing 117
Importance of indicator or tell-tale 476
Improved storage-battery construction 445

Indicator-cards

Burned-gas compression-surface 107
Detailed consideration of three-dimensional surfaces 106
Pressure-volume-quantity 105
Representation of detonation on pressure-volume-quantity 109
Work and losses 107
Influence of powerplant weight on transportation costs 334
Instrument-boards, types of taxicab 483
Insurance, automotive vehicle 596
Internal-combustion engine characteristics under high compression (J H Holloway, H A Huebotter and G A Young) 111, 354
International Air Congress 353
Investigation motor-fuels under low-temperature conditions 146
Investigation of some heavy-duty truck drive-axles (S von Ammon) 517
Involute curve development 545
Iron and semi-steel 432

Iron and Steel Division, S A E

Accepted recommendations 218
Activities 124, 125, 128, 316, 404, 407, 486, 561
Personnel 190, 262, 509, 574
Report at annual meeting 221
Report at semi-annual meeting 574
Subjects assigned 178

Isolated Electric Lighting Plant Division, S A E

Activities 561
Personnel 190, 509

J

JANEWAY, ROBERT, ON LAWS GOVERNING GASEOUS DETONATION 367, 458
JOHNSON, W M, ON STOP AND DIRECTION SIGNALS FOR MOTOR VEHICLES 475
JORDAN, E S ON GREATEST BUSINESS IN THE WORLD 308

K

Kauri reduction test 93
KEGERREIS, C S, ON EXPERIMENTAL SURVEY OF GASOLINE AND KEROSENE CARBURETION 63, 460
Kerosene Comparison of gasoline and 65
Investigations 68
KETTERING, C F, ON PROBLEMS IN FRONT OF THE AUTOMOTIVE ENGINEER 86
Knock suppressors 118

Knuckle-Pivots

Angular position of 381
Location 382

L

Laboratory determinations of varnish 92
LANDON, C L, ON COPPER-RICH BEARING ALLOYS 615
Large-section air-cushion tires 618
LARSON, J L, ON SOME EXPERIENCES IN FIRST BREAKING PEAT LAND 610
Laws governing gaseous detonation (Thomas Midgley, Jr, and Robert Janeway) 367, 458

Leather-cloth

Maintenance of uniform quality 281
Method of testing quality 277
Specifications 282

Leather Substitutes

Present state of development 276
Standardization 277
Testing top materials and 276, 449
LEE, ELISHA, ON MOTOR TRUCK AND OUR RAILROADS 151
LEE, S M, ON TESTING FUELS FOR HIGH-COMPRESSION ENGINES 11, 358
LEIGHTON, LIEUT B G, ON RECENT DEVELOPMENTS IN AIRCRAFT ENGINES IN THE NAVY 325
Letter-ballot, report on semi-annual 408

Lighting Division, S A E

Accepted recommendations 218
Activities 404, 405, 561
Personnel 190, 580
Report at annual meeting 221
Report at semi-annual meeting 580
Subjects assigned 18
Limitations of flat-rate system and piece-work system for service 201
Limitations of motorbus service 434
Limiting values of core-depth 60
Literature, survey of current 375
Living-wage for farmers 408
Loads, weight and protection of 470
Location of traffic centers 429
LOCKWOOD, E H, ON COOLING CAPACITY OF AUTOMOBILE RADIATORS 57
LOCKWOOD, E H, ON NEW INTERPRETATION OF EXHAUST-GAS ANALYSIS 299
LOUGHEAD, MALCOLM, ON FOUR-WHEEL BRAKES 611
Low-temperature operation 119

Lubricants

Axle 523
Possibilities of improvement of axle efficiency 529
Reclamation of used petroleum oils 479

Lubricants Division, S A E

Accepted recommendations 218
Activities 128, 561
Personnel 191, 509
Report at annual meeting 223
Lubrication an educational problem (G A Round) 502
Lubrication, high-speed marine engine 258

Lumber

Central committee on standards 98
Hardwood needless waste 95, 455
Standardization, hardwood 62

M

MADELUNG, GEORG H, ON DEVELOPMENT OF THE HANNOVER SAILPLANE 77
Magnetic properties of short bars, determining the 209
Maintenance activities in the Army plan 431
Maintenance effects of automotive electrical-equipment standardization (A H Packer) 283, 538
Manifolds, coat-finishing exhaust 21

Marine Engines

Accessibility 260
Accessories 260
Clutch 260
Cooling 257
Direction of rotation 261
General operation 259
Idling 259
Installation requirements 261
Lubrication of high-speed 258
Reverse-gear 260
Starting 258
Tendencies in design of high-speed 257
MATHEWS, DR JOHN A, ON PRESENT AND FUTURE OF ALLOY-STEELS 614
MATHEWS, DR JOHN A, ON STEEL 586
Mechanics, training automotive 99

Meetings

Annual at Detroit in 1924 243
Annual program 130
Automotive Transportation announced 244, 306
Automotive Transportation report 490
Chicago Service, report of 307
Council:
December, 1922 18
January, 1923 178
February 262
April 509
Motorboat announced 243
Production announced 244
S A E 167
Standards Committee 217
Summer announced 307
Tractor announced 244
Tractor, S A E, report of 499

Meetings Committee, S A E

Personnel 178
Report of annual meeting 232

Members

Addresses wanted 292
Classification of S A E 168
Membership, S A E 168

Membership Committee, S A E

Personnel 178
Report at annual meeting 231
MERCER, GEORGE J, ON CHEAPER CLOSED-BODY CONSTRUCTION 213, 450
Metals, fatigue of 123
Method of examining oil samples 348
Method of testing quality of leather-cloth 277
Metric tire-sizes 489
MIDGLEY, THOMAS, JR, ON LAWS GOVERNING GASEOUS DETONATION 367, 458
MIDGLEY, THOMAS, JR, ON PRESSURE-VOLUME-QUANTITY INDICATOR-CARD 105
Midgley, Thomas, Jr, receives Nichols medal 485
Military-airplane development and construction in peacetime (F H Russell) 296, 361
Military and commercial highway-transport (Major Brainerd Taylor) 413
Mixture adjustment and fuel waste 311
Modification of tooth-curves 552
Moisture and alkali-resistance tests of varnish 93
Molding, types of taxicab 481
Molecular-weight determination, average 289
Monoplane and biplane comparison 84
Monoplane or biplane 80
Most important problem 403

Motorboat Division, S A E

Activities 127, 561
Personnel 191, 262, 509
Motorboat Meeting, S A E, announced 243

Motorboats

Developments in construction 302
1922 and the industry 302
Tendencies in high-speed marine-engine design 257

Motorbuses

Coordination of the street railway and 433
Destructive competition between railways and 436
Limitations of service 434
Railway auxiliaries 464

Motorcycle Division, S A E

Activities 561
Personnel 191
Motor rail-cars 154
Motorships, number and tonnage of 9
Motor-transport performance with varied fuel-volatility (C T Coleman) 343
Motor truck and our railroads (Elisha Lee) 151

Motor Trucks

Development history 447
Field for 442
Permanent assets 448
Sales and operation profits 447
Statistical data 446
The "right" of the 448
What is right with the industry 446

Motor Vehicles

Anti-glare head-lamps 101
Automotive transportation by trailers 19
Common carriers 435
Critical study of modern steering-systems 377
Demountable "flats" or bodies 444
Designing cars 364
Double reflector type of head-lamp 100
Drag-link location 385
Experimental survey of gasoline and kerosene carburetion 63
Field for truck 442
Four-wheel brakes 611
French test of producer-gas trucks 85
Glare problem in Europe 100
Insurance 596
Limits of service 154
Maintenance activities in the Army plan 431
Method of examining oil samples 348
Opportunity for coordination of railroads and 152
Operation 435
Our railroads and 151
Over-loading of trucks 210
Psychology of paint in appeal of 504
Railroads not competitors of 151
Signal systems 512
Stop and direction signals for 475
Test procedure 345
Tractive resistance of 294
Traffic signaling 512
Transport performance with varied fuel volatility 343
Types of desirable 466
Typical signals 475
Unit container 442
World war transport development 413

MOYER, A F, ON NEW PRINCIPLES IN ROTATIVE BALANCE 562
MUFFLY, GLENN, ON GEAR-GRINDING AND TOOTH-FORMS 545
MURPHY, J F, ON SUCCESSFUL TRACTOR AND SEMI-TRAILER RAILROAD-TERMINAL HAULAGE 467
MURRAY, F F, ON HARDWOOD-LUMBER NEEDLESS WASTE 95, 455

N

Natural gasoline 120
Natural gasoline processes 273
Navy airship inspected 131
Navy, recent developments in aircraft engines in the 325
Nebraska tractor-test analysis (O W Sjogren) 587
New interpretation of exhaust-gas analysis (E H Lockwood) 299
New principles in rotative balance (A F Moyer) 562
New type of rail-car 303
New York center of traffic 427
Nichols medal, Midgley receives 485
1922 and the motorboat industry (H H Brautigam) 302
1922 returns to American farmers 544
Noise, gear 554

Nomenclature Division, S A E

Activities 561
Accepted recommmendations 218
Personnel 191, 509, 580
Report at annual meeting 224
Report at semi-annual meeting 580

Non-Ferrous Metals Division, S A E

Activities 561
Personnel 191

NORTHWAY, R E, ON SPRING-SUSPENSION AND SPRING MATERIALS 620
Notes on spring action 312
Number and tonnage of motorships 9

O

Off-track station construction 469
Off-track versus on-track railroad-depots 467
Officers, S A E, for 1923 160, 232

Oils

Consumption and crankcase-oil dilution 7
Crankcase dilution tests 144
Method of examining samples 348
Reclamation of used petroleum lubricating 479
Use and waste 310
World problems 122
Over-loading of motor trucks (David C Fenner) 210

P

PACKER, A H, ON MAINTENANCE EFFECTS OF AUTOMOTIVE ELECTRICAL-EQUIPMENT STANDARDIZATION 283, 538
PAGE, J F, ON AUTOMOTIVE-SERVICE CO-OPERATION BETWEEN MANUFACTURER AND DEALER 205
Paint, psychology of, in appeal of motor-car 504
Painting practice from the chemist's viewpoint (L V Pulsifer) 335
Partial-pressure calculation 289

Parts

Delivery 203
Purchasing 202
Records 202
Shipments 203
Storage system for service-station 202
Supervision of stock 205

Parts and Fittings Division, S A E

Accepted recommendations 218
Activities 124, 125, 126, 127, 404, 487, 561
Personnel 191, 581
Report at annual meeting 224
Report at semi-annual meeting 581
Subjects assigned 18

Passenger-Car Body Division, S A E

Accepted recommendations 218
Activities 126, 127, 315, 404 486, 487, 489, 561
Personnel 191, 315
Subjects assigned 18

Passenger-Car Division, S A E

Activities 316, 404, 561
Personnel 191
Passenger-car developments and prophecies (F E Watts) 177
Passenger-carrying flying-boat operation (H A Bruno) 351
PATTON, EDWARD, ON PSYCHOLOGY OF PAINT IN THE APPEAL OF THE MOTOR CAR 504

Peacetime

Government's problem 297
Military-airplane development and construction in 296, 361
Peat land, some experiences in first breaking 610
Personnel of 1923 Standards Committee, S A E 189
PETERSON, C G, ON IMMEDIATE POSSIBILITIES OF COMMERCIAL AIRPLANE SERVICE 263, 359

Petroleum

Cracking processes in the industry 510
Products 544
Reclamation of used lubricating oils 479
Petroleum and automotive engineers discuss common problems 118
Petroleum products 544
Piston-ring click 170

Pistons

Engine 46
Seasoning cast-iron 171
Pitch-diameter 553
Plywood roof construction 483
Port-arrangement for in-line engines 37
Portland cement, record production of 472
Post-war transportation 420
Power cultivators 600
Powerplant type, choice of 52
Power, wave transmission of 484
Practical research 559
Pre-war transportation 413
Present and future of alloy-steels (Dr John A Mathews) 614
Present status of fuel problem 120
Presidential address of B B Bachman 167
Pressure-volume-quantity indicator-card (Thomas Midgley, Jr) 105
Pressures in gaseous explosions 319
Price revision for service 200

Prices

Economic reason for high hardwood 97
Spread in producers' and consumers' 596
Problems in front of the automotive engineer (C F Kettering) 86
Producer gas, French test of trucks 85
Producers' and consumers' prices, spread in 596
Production engineer 472
Production session, S A E 167

Production

Engineer 472
Experience notes from a notebook 22
Record, of Portland cement 472

Profession

Automotive work as a 17
What constitutes a 17
Progress 334
Proper utilization of natural gasoline (L F Bayer) 273
PROSSER, DR C A, ON AUTOMOTIVE WORK AS A "PROFESSION" 17
Psychology of paint in the appeal of the motor car (Edward Patton) 504
Public and government 118
Publication Committee, S A E, personnel 178
PULSIFER, L V, ON AUTOMOBILE FINISHING-VARNISH 89, 335, 456
PULSIFER, L V, ON PAINTING PRACTICE FROM THE CHEMIST'S VIEWPOINT 335
Purchasing of automobile parts 203

Q

Quantity of air for cylinder 43
Questions answered by the Research Department 21, 170

R

Race track, engineering information from the 616

Radiator Division, S A E

Activities 127, 315, 561
Personnel 191

Radiators

Classification of 57
Comparison of cooling capacity 59
Cooling-capacity charts 60
Cooling capacity of automobile 57
Experiments on cooling capacity of 58
Limiting values of core-depth 60
Measurements of cores 58
Steam condensation 61
Thermo-syphon cooling 59
Radio broadcast of dinner speeches 131, 245
Rail-car, new type of 303
Railroad-depots, off-track versus on-track 467
Railroad fares reduced 131
Railroad-terminal haulage, successful tractor and semi-trailer 467
Railroads and motor vehicles 151

Railroads

Handling semi-trailers at depots 470
Motor vehicles not competitors of 151
Off-track versus on-track depots 467
Opportunity for coordination of motor vehicles and 152
Reduced fares to summer meeting 618
Railway-terminal trucking, English cartage-practice a standard for our 437
Rate of descent, analysis of 78
Rating of tractors 587
Recent developments in aircraft engines in the Navy (Lieut B G Leighton) 325
Reclamation of used petroleum lubricating oils 479
Record production of Portland cement 472
Repair-job order-form 195
Repair parts 199
Reports of Divisions to Sandards Committee 565

Reports

Action on Standards Committee Division 218
Divisions to Standards Committee 565
Meetings Committee at annual meeting 232
Membership Committee at annual meeting 231
Sections Committee at annual meeting 233

Semi-annual letter-ballot on standards 408
Standards Committee at annual meeting 231
Treasurer's annual 10
Resale value of automobiles 10
Research foundation for the economic theory of highway improvement (W K Hatt) 294
Research reduces highway costs 129
Research session at annual meeting 241

Research

Advisory board on highway 294
Connection of the Research Committee with fuel 207
Financial support and program 207
For automotive engineers 294
Highway engineer and 294
National Automobile Chamber of Commerce and automobile associations 294
Practical 559
Public and Government 118
Reduces highway costs 129
S A E 168
S A E sheds new light on fuel problem 211
To promote economy of fuel 311

Research Committee, S A E

Connection with fuel research 207
Personnel 262
Reserve Officers Training Corps 511
Reserve-ratio of Federal Reserve Banks 341
Reserve resources 206
Resistance of motor vehicles, tractive 294
Responsibility of driver 311
Retailer and the engineer (Harold B Wess) 465
Reserve-gear, marine engine 260

Roads and Highways

Advisory Board on Highway Research 294
Army plan of transport 421
Automobile associations and research 294
Automotive engineer and research 294
Building policy 153
Economics 76
Federal agencies and research 294
Federal money 122
Formation of transport centers 429
Highway engineer and research 294
Locating highway engineer and research 294
Military and commercial transport 413
National Automobile Chamber of Commerce and research 294
Research foundation for the economic theory of improvement 294
Research reduces costs 129
Testing car performance on 448
Traffic in a city 612
Traffic recommendations 474
Transportation most important problem 403

Roofs

Construction of plywood 483
Types of taxicab 481
Rotative balance, new principles in 562
ROUND, G A, ON LUBRICATION AN EDUCATIONAL PROBLEM 502
Routing of shop orders 198
Rural credits 301
RUSSELL, F H, ON MILITARY-AIRPLANE DEVELOPMENT AND CONSTRUCTION IN PEACETIME 296, 361

S

S A E

Annual meeting program 130
Annual report of treasurer 10
Automotive Transportation Meeting announced 244, 306
Automotive Transportation meeting papers 306
Automotive Transportation meeting program 399
Automotive Transportation meeting, report of 490
Chicago Service meeting, report of 307
Classification of members 168
Council meetings:
December, 1922 18
January, 1923 178
February 262
April 509
Current standardization work 124, 315, 404
Finances 169
Handbook 560
In Australia 489
Interest in fuel economy 310
Meetings 167
Membership 168
Motorboat meeting announced 243
Officers for 1923 160, 232
Production meeting announced 244
Railroad fares reduced 131
Reports of Divisions to Standards Committee 565
Research 168
Research sheds new light on fuel problem (V H Gottschalk) 3, 211
Standardization procedure 560
Summer meeting announced 307, 503
Tractor meeting announced 244, 398
Tractor meeting, report of 499
Safety and comfort as inducements to air travel (R R Blythe) 342

Safety

Airplane 157
Comfort and, as inducements to air travel 342
Steering-systems 377

Sailplane

Analysis of the rate of descent 78
Constructional details 82
Development of the Hannover 77
Form and arrangement of body 81
Model test 81
Monoplane or biplane 80
Section and best-chord determination 79
Static tests and factor of safety 83
Torque 82
Screw-Thread Division, S A E, activities 561

Sections Committee, S A E

Personnel 178
Report at annual meeting 233
Sections, S A E, management 168
SEGNER, C B, ON STATIONARY INTERNAL-COMBUSTION ENGINEERING DEVELOPMENTS 304
Selection of axle *B* 534
Selling transportation 471

Semi-trailers

Handling at railroad depots 470
Successful tractor and, railroad-terminal haulage 467
Tractor movement-control and 470
Tractor operation and 469
Weight and protection of loads 470
Service and its relation to the industry (Otis C Funderburk) 265, 535

Service

Automotive cooperation between manufacturer and dealer 205
Causes of poor 193
Cleanliness 204
Control chart 201
Development of a modern system 193, 539
Flat-rate system of charges 194, 271
Follow-up on repair-jobs 203
General results 204
Good, as a sales asset 193
Guarantee or policy work 201
Handling work in the shop 270
Its relation to the industry 265, 535
Limitations of flat-rate system and piece-work system 201
Modern equipment and trained personnel necessary 266
New attitude toward 193
Operation data 195
Parts department 202
Parts records 202
Price revision 200
Proposed improvement 284
Purchasing of parts 203
Repair-job order-form 195
Repair parts 199
Routing of shop orders 198
Securing cost data 271
Shipments and deliveries of parts 203
Some special equipment 267
Standardization problems 284
Timekeeping 199
Timekeeping system 195
24-hr. service on Ford cars 265
Seventh semi-annual gasoline survey 397
Shipments and deliveries of automobile parts 203
Signal systems 512

Signals

Characteristics of a satisfactory 476
Essentials of system design 476
Importance of indicator or tell-tale 476
Importance of minimum electrical resistance 479
Stop and direction for motor vehicles 475
Typical motor vehicle 475
Simplification 169
Simplification Conference Committee 365
SJOGREN, O W, ON NEBRASKA TRACTOR-TEST ANALYSIS 587
Sleeve-valve type engines 38
Social worth and service 18
Society's research sheds new light on fuel problem (V H Gottschalk) 3, 211
Some causes of gear-tooth errors and their detection (K L Herrmann) 26
Some experiences in first breaking peat land (J L Larson) 610
Some unique features of automobile production (William Dunk) 25
South America, progress of standardization in 217
Spark-plugs, engine 46
SPARROW, S W, ON TESTING FUELS FOR HIGH-COMPRESSION ENGINES 11, 358

Specifications

Gasoline 118
Leather-cloth 282
Speed and comfort of airplanes 158
Speeds, tractor belt 588
Spread in producers' and consumers' prices 596
Spring-suspension and spring materials (R E Northway) 620
Springs 595
Springs, notes on action 312

Springs Division, S A E

Activities 126, 561
Personnel 192
Standardization of oil-field equipment 216

Standardization

Current work 124, 315, 404
Hardwood lumber 62
Leather-cloth 277
Maintenance effects of automotive electrical-equipment 283, 538
Oil-field equipment 216
Problems in electrical equipment 284
Progress in South America 217
S A E procedure 560
Simplification and 169
Simplification Conference Committee 365
Tentative work 486
Standardized mental test in personnel selection (Dr W V Bingham) 272
Standards, central committee on lumber 98
Standards Committee meeting 217

Standards Committee, S A E

Action on Division reports 218
Attendance at annual meeting 230
Current work 561
Data sheets, March 1923 issue of 407
Initiation and procedure 560
Personnel of 560
Personnel of 1923 189
Report at annual meeting 231
Report of semi-annual letter ballot 408
Reports of Divisions 565
S A E Handbook 560
Starting, marine engines 258

Stationary-Engine Division, S A E

Activities 127, 407, 561
Personnel 192, 585
Report at semi-annual meeting 585
Stationary internal-combustion engineering developments (C B Segner) 304
Steel (Dr John A Mathews) 586

Steels

Abrasive qualities of 76
Iron and semi 432
Present and future of alloy 614
Tensile properties of low-carbon 192
Wear of 366
Steering, causes of hard 378
Steering-gear types, comparison of 386

Steering Systems

Angular position of knuckle-pivots 381
Causes of hard steering 378
Comparison of gear types 386
Critical study of modern automotive-vehicle 377
Drag-link location 385
Irreversibility 385
Location of knuckle-pivot 382
Safety 377
Tie-rod arms and tie-rods 388

Stock department supervision 205
Stop and direction signals for motor vehicles (R N Falge and W M Johnson) 475

Storage-Battery Division, S A E

Accepted recommendations 218
Activities 561
Personnel 192
Report at annual meeting 224

Storage-Batteries

Improved construction 445
Sulphation rate of plates 403
Successful tractor and semi-trailer railroad-terminal haulage (J F Murphy) 467
Sulphation rate of storage-battery plates 403

Summer Meeting, S A E

Announced 307, 503, 617
Four-wheel brake session 618
Head-lamp glare session 618
Large section air-cushion tire session 618
Reduced railroad fare 618
Spring Lake road maps mailed 618
Swimming carnival 618
Superposition of vibrations 314
Survey of current literature 375
Swayne, Alfred H, address 498

T

Taxation on a tire consumption basis 61
Taxicab-body construction (Hugh G Bersie) 480

Taxicabs

Body construction 480
Construction of plywood roof 483
Costs and records 483
Methods of joining frame members 481
Methods of securing durability 480
Types of dash and instrument-board 483
Types of hardware and molding 481
Types of roof 481
Wood suitable for body framework 481
TAYLOR, MAJOR BRAINERD, ON MILITARY AND COMMERCIAL HIGHWAY-TRANSPORT 413
Temperature, cylinder 38
Tendencies in high-speed marine-engine design (J G Vincent) 257
Tensile properties of low-carbon steel 192
Tentative standardization work 486
Terminals necessary, adequate 467
Terrain for glider contests 275
Test of air-cleaners for tractor engines 376
Testing fuels for high-compression engines (S M Lee and S W Sparrow) 11, 358
Testing gear-grinding accuracy 550
Testing leather substitutes and top materials (J B Davis) 276, 449
Testing road performance 448

Tests

Air-cleaners for tractor engines 376
Apparatus for gaseous detonation 370
Automobiles 3, 140
Continuation of fuel 208
Cooling capacity of radiators 58
Crankcase-oil dilution 144
Drying and safety of varnish 92
Equipment and apparatus for engine 114
Former and present aircraft engine 326
French, of producer-gas trucks 85
Fuel-consumption 140
Fuels 3
Fuels for high-compression engines 11
Fuels used 140
Gear dimension 185
Gear-grinding accuracy 550
High-compression engine preformance 112
Impact 117
Kauri reduction 93
Leather substitutes and top materials 276, 449
Limits of accuracy of fuel 6
Methods and equipment of axle 520
Methods of engine 11
Moisture and alkali-resistance 93
Motor-fuels under low-temperature conditions 146
Motor-vehicle procedure 345
Nebraska tractor analysis 587
Present status of fuel problem 120
Procedure of automobile 4
Procedure of axle 521
Procedure of engine 115
Program of axle 522
Quality of leather-cloth 277
Reliable and otherwise 374
Results of axle 523
Result of engine 116
Results of gasoline 274
Results of tractor 594
Road 208
Road performance 448
Sailplane 81
Standardized mental in personnel selection 272
Static and factor of safety 83
Thermo-syphon cooling 59
THOMPSON, STEPHEN G, ON WHAT IS RIGHT WITH THE MOTOR-TRUCK INDUSTRY 446
Tie-rod arms and tie-rods 388
Timekeeping 199
Timekeeping system for service 195

Tire and Rim Division, S A E

Personnel 509
Subject assigned 509

Tires

Large-section air-cushion session at Summer Meeting 618
Metric sizes 489
Old and new 595
Taxation on a consumption basis 61
Toe-in or foregather of wheels 382
Tonnage of motorships number and 9
Tooth-cuves, modification of 552
Tooth-forms, gear-grinding and 545
Tooth-spacing 551
Torque 82
Tractive efficiency 588
Tractive resistance of motor vehicles 294
Tractor industry in 1922 (O W Young) 188

Tractor Meeting, S A E

Announced 244, 398
Luncheon 501
Report of 499

Tractors

Accessories 594
Belt speeds 588
Chassis 594
Crawler type general-purpose 604
Defects of 593
Design fundamentals 188
Engines 593
Fuel and water consumption 592
General-purpose farm 597
Industry in 1922 188
Internal-combustion-engine application 598
Light 598
Nebraska test analysis 587
Other types 605
Rating of 587
Recent general-purpose types 607
Results of tests 594
Semi-trailer and, movement-control 470
Semi-trailer and, operation 469
Slippage of drive-wheels 590
Successful semi-trailer and, railroad-terminal haulage 467
Test of air-cleaners for engines 376
Tractive efficiency 588
Two phases of engineering 188
Weight and protection of loads 470
Weight distribution 588
Traffic 272

Traffic and Transportation

Adequate terminals necessary 467
Amplification of the Army study 430
Army plan of highway 421
Automotive by trailers 19
Automotive development 468
Center of New York 427
Changing aspect of 447
Commercial organization under the Army plan 428
Cost of 436
Demountable "flats" or bodies 444
Development of Army plan 426
Distance of haul and economy of operation 471
Engineering aspects of 473
Factors in the problem 437
Field for the motor truck 442
Formation of highway centers 429
Highway recommendations 474
Highway in a city 612
Horse 442
Influence of powerplant weight on costs 334
Location of centers 429
Maintenance activities in the Army plan 431
Military and commercial highway 413
Most important problem 403
Motor performance with varied fuel-volatility 343
Passenger by trailers 20
Post-war 420
Pre-war 413
Selling 471
Signal systems 512
Signaling 512
Stop and direction signals for motor vehicles 475
Successful tractor and semi-trailer railroad-terminal haulage 467
Unit container 442
War-time 414
World war motors development 413
Traffic signaling 512

Trailers

Automotive transportation by 19
Cost of operation 20
Passenger transportation 20
Training automotive mechanics 99
Transactions, order blank for 293
Transfer of energy 86

Transmission Division, S A E

Accepted recommendations 218
Activities 404, 488, 561
Personnel 192
Report at annual meeting 225
Transmission wave, of power 484
Treasurer's annual report, S A E 10, 232

Truck Division, S A E

Accepted recommendations 218
Activities 126, 315, 404, 561
Personnel 192, 262, 509, 584
Report at annual meeting 225, 230
Report at semi-annual meeting 584
Trucking, English cartage-practice a standard for our railway-terminal 437
Trucks, investigation of some heavy-duty drive-axles 517

U

Unified control of cartage 444
Unit container 442
Urban industries, farm and 76
Usage of natural gasoline 273
Utilization of existing farm equipment 606

V

Valve-gears, arrangement 38
Valve location and type of finning 32

Valves

Cooling of exhaust 40, 51
Internally cooled 51
Location and type of finning 32
Vapor-pressure measurement 288

Varnish

Automobile finishing 89, 335, 456
Drying and safety of working tests 92
Elasticity 91
Estimation of service qualities 91
Film factor 91
Kauri reduction test 93
Moisture and alkali-resistance tests 93
Non-volatile content 92
Qualities to be desired 89
Resistance to moisture and alkalis 91
Service qualities 90
Shop qualities 89

Vibration

Periods of automobile 312
Superposition of 314
VINCENT, J G, ON TENDENCIES IN HIGH-SPEED MARINE-ENGINE DESIGN 257

Volatility

Economic motor-fuel 139
Effects of fuel investigated 312
Fuel 209
Further data on the effective, of motor-fuels 287
Motor-transport performance with varied fuel 343
VON AMMON, S, ON INVESTIGATION OF SOME HEAVY-DUTY TRUCK DRIVE-AXLES 517

W

Wage-incentive plan, group-bonus 27
Wages, living for farmers 408
WARNER, E P, ON DESIGN OF COMMERCIAL AIRPLANES 155, 863
Water consumption of tractors 592
Water-cooled versus air-cooled engine 332
WATTS, F E, ON PASSENGER-CAR DEVELOPMENTS AND PROPHECIES 177
Wear of steels 366

Weight

Distribution of, in automobiles 314
Distribution of tractor 588
Influence of powerplant on transportation costs 334
In general 596
Reduction in aircraft engine 329
WENNERLUND, E KARL, ON GROUP-BONUS WAGE-INCENTIVE PLAN 27
Wheel-wabble 384

Wheels

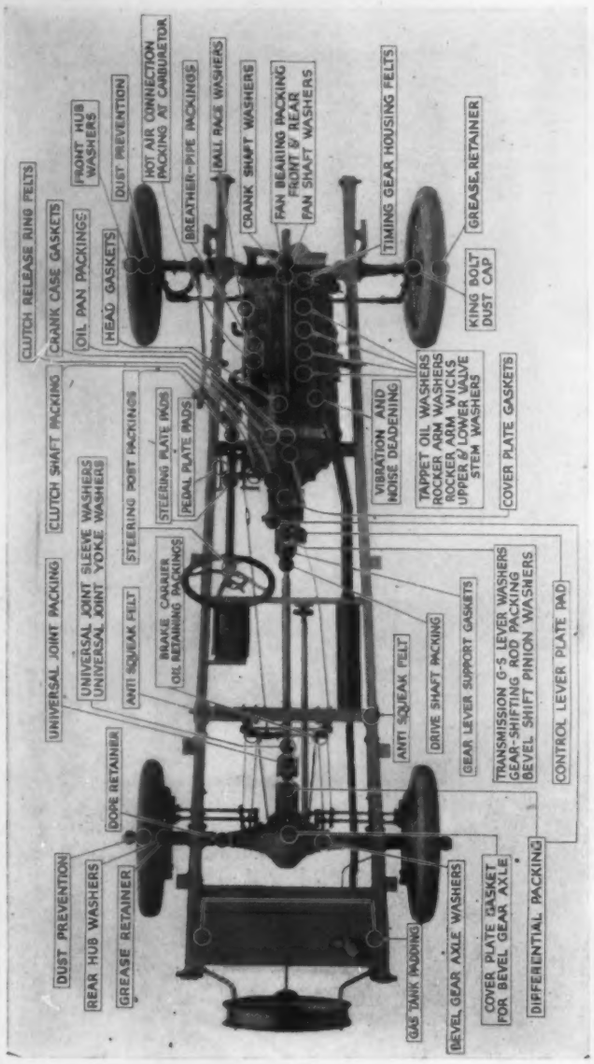
Axles and 595
Castering or trailing effect 382
Foregather or toe-in of 382
Slippage 590
WILSON, ROBERT E, ON FURTHER DATA ON THE EFFECTIVE VOLATILITY OF MOTOR-FUELS 287
World oil-problems 122

Y

YOUNG, G A, ON EXPERIMENTAL SURVEY OF GASOLINE AND KEROSENE CARBURETION 63, 460
YOUNG, G A, ON INTERNAL-COMBUSTION ENGINE CHARACTERISTICS UNDER HIGH COMPRESSION 111, 354
YOUNG, O W, ON TRACTOR INDUSTRY IN 1922 188

KERITE
A product of over fifty years distinguished service in the most important electrical fields, possessing inherent characteristics which make it pre-eminently desirable for
High Tension Automotive Ignition
DAYS KERITE
KERITE
INSULATED WIRE & CABLE
COMPANY
NEW YORK CHICAGO
KERITE
COMPANY

A Trouble Chart



This illustration shows less than half of the places on a typical chassis of current production where practically all automobile manufacturers in the industry have found trouble develop in lubrication—grease retention and dust prevention—and with noise.

The *AMERICAN FELT COMPANY* has correctly solved the difficulties arising at these and other points; it has often reduced costs and minimized service expense; it has improved the quality of the whole vehicle and raised the standard of satisfaction to the user to a most appreciable extent.

Do you recognize any of the spots indicated above as "weak" points in the car *you* build? Do you want expert assistance in correcting the faults? Our organization is at your service—a letter or call at our nearest office will start the wheels moving for you.

American Felt Company
TRADE MARK

CHICAGO—325 S. Market St.
DETROIT—1915 Fort St., West
ST. LOUIS—1627 Locust St.
NEW YORK—114 E. 13th St.
PHILADELPHIA—37 Drexel Bldg.
BOSTON—211 Congress St.
CINCINNATI—1 Greenwood Bldg.
SAN FRANCISCO—833 Market St.

Personal Notes of the Members

Items regarding changes in business connections, promotions, etc., are desired from the membership for insertion in these columns. This will enable members to keep their friends informed of their whereabouts and will also assist in keeping the records of the Society up to date.

E. C. Arndts has been appointed district sales manager with headquarters at Cleveland for the metal cleaning division of the Crescent Washing Machine Co., New Rochelle, N. Y.

H. A. Best, who until recently was sales representative at Chicago for the Sheldon Axle & Spring Co., Wilkes-Barre, Pa., is now located at the Detroit office of the Spicer Mfg. Corporation, Plainfield, N. J.

A. D. Chandler, who was formerly sales engineer for the Pharo Mfg. Co., Detroit, is now associated with the Beaver Mfg. Co., Milwaukee, Wis.

F. F. Chandler, for many years manager of sales and advertising with the Chandler & Taylor Co., Indianapolis, Ind., has resigned and on May 1 became associated with the Ross Gear & Tool Co., Lafayette, Ind.

Rene L. Cros, who formerly attended the Ohio State University, Columbus, is doing final inspection work at the Delco-Light Co., Dayton, Ohio.

Harry S. Durland, until recently associated with the Wright Aeronautical Corporation, Paterson, N. J., in connection with foundry production and equipment, is now an editorial assistant with *Bus Transportation*, New York City.

Frank L. Eidmann, who returned a short time ago from a trip around the world, as mentioned in the April issue of THE JOURNAL, has been appointed associate professor in mechanical engineering at Princeton University, Princeton, N. J.

Harry Fosdick has been appointed manager of Boston retail sales for the Sills-Chevrolet Co., Boston. He was formerly vice-president and sales engineer for Paul Le Hardy, Inc., Rochester, N. Y.

Herbert A. Goddard has severed his connection with the Sinclair Motors Corporation, New York City, where he was vice-president and director of sales. No announcement has been made of his future plans.

H. B. Griffin, who was until recently associated with the Light Mfg. & Foundry Co., Pottstown, Pa., has accepted a position in the Detroit office of the Doehler Die-Casting Co., Brooklyn, N. Y.

Reno Haibe has become affiliated with the service department of the Cole Motor Car Co., Indianapolis. He was previously master mechanic with the Inglis & Lytle Construction Co., Jacksonville, Fla.

John J. Henry, who was until recently engineer in charge for the Bethlehem Motors Corporation of New York, Pottstown, Pa., has become chief inspector for the Ward Motor Vehicle Co., Mt. Vernon, N. Y.

(*Continued on p.* 4)

DIXON'S 677

is an economical Transmission and Rear Axle Lubricant of exceptional long life.

Its use means that original factory adjustments of transmission and rear axle may be maintained for a greater period of time because of this long life.

The use of a short-life lubricant presents the necessity of changing factory adjustments with the possible danger of not getting the proper alignment of parts.

JOSEPH DIXON CRUCIBLE COMPANY

Jersey City, N. J. *Established 1827*

MAKERS OF QUALITY LUBRICANTS

For Spur and Bevel Gears Use Dixon's Gear Lubricant No. 677
For Worm Drives Use Dixon's Gear Oil No. 675
For Universal Joints Use Dixon's Grease No. 672

Gar Wood Says:
"That over 90% of all truck makers advise Wood-Detroit Dumping Equipment is due to its superior design; that over 90% of users specify Wood-Detroit is proof of its superior service."

Gar Wood

Built by "Gar" Wood

Friction losses and lubrication problems are insignificant with only three moving parts—a piston and two pump gears—at all times working in oil, in

WOOD DETROIT

Hydraulic Hoists

The serviceability that this simplicity and efficiency has given to Wood-Detroit Hoists and the sturdiness of these units and of the Wood-Detroit Steel Bodies, is responsible for their leadership since the earliest days of the industry.

Wood Hydraulic Hoist & Body Company

7924 Riopelle St. Detroit, Michigan

Sales and Service in Principal Cities

PERSONAL NOTES OF THE MEMBERS

Continued

J. Q. Holmes has joined the process department of the Remy Electric Co., Anderson, Ind. He was formerly engaged in experimental work with Robert H. Hassler, Inc., Indianapolis.

C. L. Huening, who was previously in charge of the specification department of the Mitchell Motors Co., Inc., Racine, Wis., has joined the engineering department of the Auburn Automobile Co., Auburn, Ind.

J. J. Kohl, who was at one time assistant manager of the City Machine & Tool Works, Dayton, Ohio, and more recently general manager of the Vulcan Tool Co., also of Dayton, and **M. T. Ahlers,** formerly assistant chief engineer of the City Machine & Tool Works, and later production engineer of the Columbus Auto Parts Co., Columbus, Ohio, have organized the International Tool Co. with a shop at Dayton.

Kenneth M. Lane has accepted a position as aeronautical engineer with the Wright Aeronautical Corporation, Paterson, N. J. He previously held a similar position with the Dayton Wright Co., Dayton, Ohio.

S. Vance Lovenstein, president and general manager of the Schwarz Wheel Co., Philadelphia, joined the Eugene McGuckin Co., also of Philadelphia, as vice-president on June 1.

Dorr Miller is connected with engineering and sales for the Q & C Co., New York City. Prior to this he was an engineer for the Toledo Automotive Products Co., Toledo.

H. L. Montanya, who was formerly chief inspector for the Yard-O-Meter Corporation, St. Louis, has accepted a position as general foreman of the tools, dies, jigs, fixtures and special machinery departments of the Columbus Die Tool & Machine Co., Columbus, Ohio.

J. G. Murphy has severed his connection with the Anderson Motor Co., Rock Hill, S. C. No announcement has been made of his future plans.

L. F. Nielsen, manager and mechanical engineer of the Equitable Engineering Co., announces the removal of the offices of that company from 103 First Avenue, North, to 15 Wilder Street, Minneapolis.

F. H. Norton, who was formerly chief physicist for the National Advisory Commission for Aeronautics, Langley Field, Va., is now affiliated with Massachusetts Institute of Technology, Cambridge, Mass.

Sidney Oxberry, for the past 4 years art editor of *Motor,* New York City, has resigned and sailed for an indefinite stay in England. Prior to his association with *Motor* he was a member of the editorial staff of *Automotive Industries.*

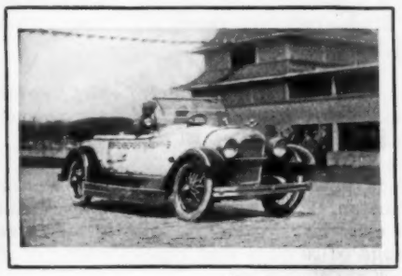
E. F. Paepper, who was an engineer for the Yellow Cab Mfg. Co., Chicago, has been promoted to the position of assistant chief engineer.

Etienne Planche has resigned as chief engineer of the Dort Motor Car Co., Flint, Mich., a position he has held for the past 9 years. He has opened an office as consulting engineer in the General Motors Building, Detroit.

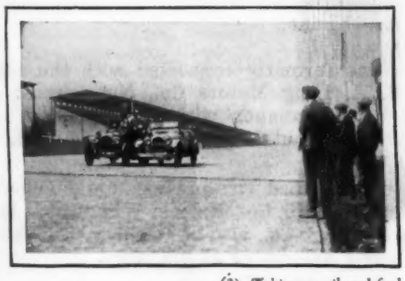
R. C. Plexico has accepted a position as assistant engineer and chief draftsman for the Warner Gear Co., Muncie, Ind. He was formerly assistant chief engineer for the Anderson Motor Co., Rock Hill, S. C.

(*Continued on p.* 6)

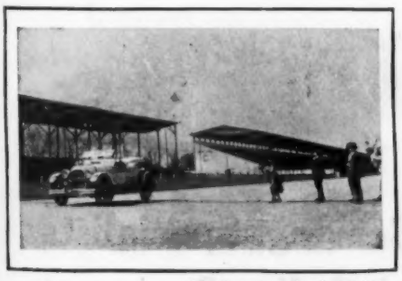
The Duesenberg Straight Eight, regular stock model, immediately after the Record-Breaking Performance



(1) *Speeding away to the remarkable Record*



(2) *Taking on oil and fuel at fifty miles an hour!*



(3) *Crossing the finish line. Another American Record!*

A Duesenberg Stock Car World's Record With S. R. B. Bearings!

New World's Record Stock Car Endurance Run, 3155 miles in 50 hours 21 minutes and 1 second!
Non-stop
Average speed 62-63 M. P. H.
Indianapolis Speedway, April 27-29, 1923

A GRINDING, grueling test putting a terrific strain upon every moving part!

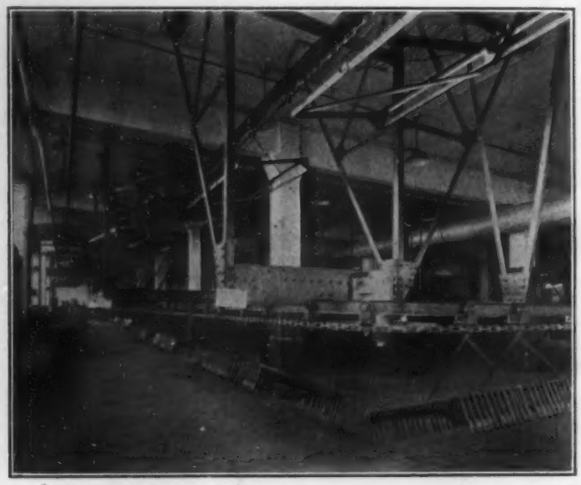
Sturdy S. R. B. Bearings, both Double and Single Row, taken from Duesenberg regular stock, bore the brunt of friction attack at nine important points:

Front Axle, inner	S. R. B.
Front Axle, outer	S. R. B.
Clutch Release Bearing	S. R. B.
Transmission Rear Main Shaft	S. R. B.
Propeller Shaft	S. R. B.
Pinion Shaft, front (double row)	S. R. B.
Pinion Shaft, rear (double row)	S. R. B.
Differential Carrier (2)	S. R. B.
Wheel Bearing Rear Axle	S. R. B.

SRB

STANDARD STEEL AND BEARINGS INCORPORATED
OPERATING UNDER CONRAD PATENTS
PHILADELPHIA **PENNA., U. S. A.**

S. R. B. Bearings are serviced by the branches of the Standard Sales and Service Co. throughout the United States



A Section of Windshield Conveyor installed at Ternstedt Mfg. Co. Detroit. Aids in the production of 3000 Windshields in 8¾ hrs.

Equipment That Cuts Labor Costs in Half

This is an example of the service rendered by The Jas. F. Miller & Hurst Corporation.

In the design and construction of the Windshield Conveyor illustrated above we successfully solved a problem in quantity production at reduced labor and operating costs. A crying need in the automotive industry to-day.

The whole conveyor is 1200 feet long, yet so nicely balanced and adjusted that it carries 3000 Windshields per day through a series of baking and enameling ovens as well as dip tanks and other processes—all this on less than 1½ H. P.

The design of the equipment in this plant has reduced expensive hand labor by half—has materially lowered stock-in-process investment and has established another record for low production costs.

Our experience in planning for greater profits in the largest foundries and industrial plants in the automotive industry is available to you.

Let us show you how similar practices and installations will increase production and decrease costs in your plant.

Write for further information on "Modern Production Methods."

THE JAS. F. MILLER & HURST CORPORATION

DESIGNERS :: BUILDERS :: ORGANIZERS

Quantity Production Foundries and Industrial Plants

GENERAL MOTORS BUILDING
DETROIT, MICH.

PERSONAL NOTES OF THE MEMBERS

Concluded

Alfred J. Poole has severed his connection with the Simms Magneto Co., East Orange, N. J., where he was sales manager. No announcement has been made of his plans for the future.

Finley R. Porter has become associated with the Humphreys Oil Co., Mexia, Tex.

I. D. Rocap, a partner in the firm of Lynch & Rocap, City of Washington, announces a dissolution of the partnership after a sale of the business. His future plans have not been announced.

Porter E. Stone has become affiliated with the Highland Body Mfg. Co., Cincinnati.

Charles H. Tavener, who was formerly agent for the Adams Trailer Corporation, Garden City, N. Y., has been appointed production manager of the Liberty Electric Corporation, Port Chester, N. Y.

George J. Thomas is no longer chief engineer for the Duplex Truck Co., Lansing, Mich., but has become affiliated with the Power Truck & Tractor Co., St. Louis.

H. E. Thompson has accepted the position of chief engineer with the H. E. Thompson Co., Indianapolis. He was formerly job engineer for the Standard Oil Co., El Segundo, Cal.

Joseph C. Towler is now associated with the Packard Motor Car Co. of Boston, Worcester, Mass., doing testing, trouble-shooting and electrical work. He was formerly service manager in charge of service and repair work for the Autolec Co., Inc., also at Worcester.

Erwin A. Weiss has resigned from the Mitchell Motors Co., Inc., Racine, Wis., where he was assistant chief engineer, and is now connected with the engineering department of the Yellow Cab Mfg. Co., Chicago.

S. P. Welch, who was formerly connected with the sales department of the R. H. Long Motors Co., Newark, N. J., has been appointed sales manager with headquarters at Elizabeth, N. J., of the Regina Corporation, Rahway, N. J.

F. M. Young has been elected vice-president and general manager of the Racine Radiator Co., Racine, Wis., which has succeeded the Perfex Radiator Co., also of Racine, with which Mr. Young was previously associated as manager.

THE BANTAM BALL BEARING CO.

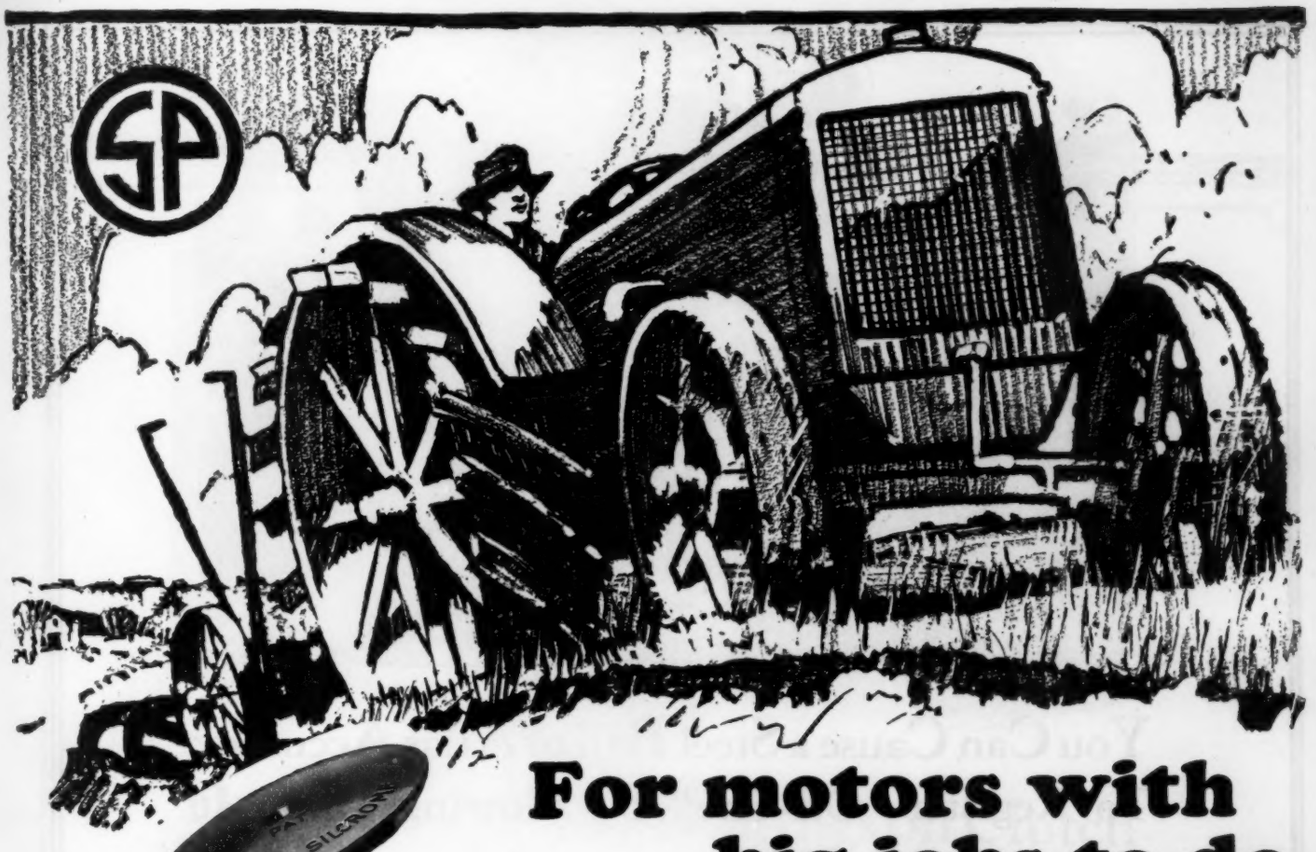
BANTAM, CONN., U.S.A.

Thrust Bearing Specialists

Bearings Made To Your Requirements

DETROIT OFFICE:
905 Dime Bank Bldg.
Detroit, Mich.

PACIFIC COAST:
Frank M. Cobbledick Co.
1031 Polk St., S. F., Cal.



For motors with big jobs to do

There are 400,000 tractors in use on farms of the United States. Total value of 1922 farm crops, $8,961,000,000. Total value of all farm property, $77,924,000,000. Total number of farms 6,448,343

IN the performance of the great tasks of industry, when motors must work under conditions of prolonged abnormal strain, the indestructibility of *Thompson Silcrome Valves* becomes most evident.

Red-hot temperatures which burn away the seats of other valves have no effect on valves of *Thompson Silcrome.*

Friction actually quadruples their wear-resistance by a unique process of surface polishing. Internal stresses that cause warping are absent from this steel.

Investigate *Thompson Silcrome Valves.* Put them in test motors. Try to run them to failure. Then specify "*Thompson Silcrome*". For double protection use the *two* words!

Non-burning
Non-warping
Non-scaling
Non-air-hardening
Weigh least
Wear longest
Moderately priced

—built by a "trail-breaker of industry"

THOMPSON SILCROME VALVES

THE STEEL PRODUCTS COMPANY

MAIN PLANT
CLEVELAND

Also manufacturers of king bolts, shackle bolts, tie rod bolts, drag links, starting cranks, and brake rod assemblies

MICHIGAN PLANT
DETROIT

You Can Cause a Steel Ball of Atlas Accuracy To Register "Off-Size" by Blowing Upon It

RAISING a half inch Atlas Steel Ball to body temperature by holding it in one's hand or by blowing one's breath upon it, is sufficient to cause it to register "off-size" when mixed with others of the same lot held at a room temperature of 70 degrees.

Yet the expansion of a half-inch ball when raised from normal room temperature to that of the body is only about eight hundred thousandths of an inch (.00008″). But Atlas Balls must not deviate from true size by more than five hundred thousandths of an inch (.00005″) generally expressed as one half of 1/10,000″.

With the exception of Johannson gauge blocks such accuracy is seldom equalled or even approached in industrial machine elements. So great is the care exercised in the manufacture and gauging of Atlas Balls that after burnishing they are not touched by hand and are gauged in a room held at a constant temperature.

It is because of this great accuracy, the mirror-like finish and high resistance against fatigue that Atlas Steel Balls have won the enthusiastic endorsement of the most exacting ball users.

ATLAS BALL COMPANY

Glenwood Ave. at Fourth St. - - - Philadelphia

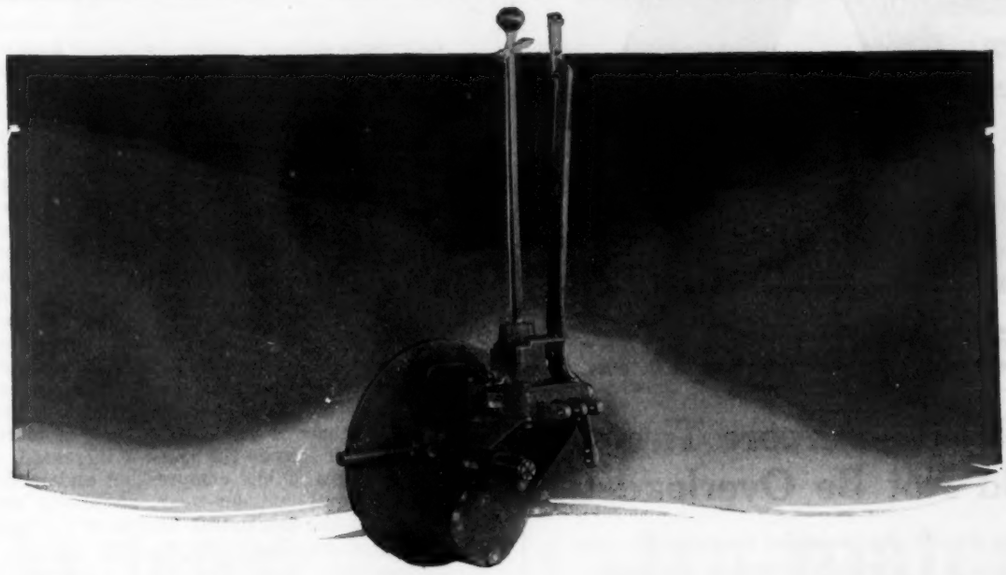
951

ATLAS STEEL BALLS

ALSO BRASS, BRONZE, MONEL AND SPECIAL METALS

Made Under
SKF
Supervision

SKF



Deep-Groove Ball Bearings on Clutch Shaft Take Both Radial and Thrust Loads

A DEEP-GROOVE ball bearing made by the Hess-Bright Manufacturing Company is used as the rear bearing on this clutch shaft, taking a radial load under normal conditions and a thrust load when the clutch pedal is depressed thereby insuring quietness of operation.

The ability of this type of bearing to take both loads is due to its deep grooves of uniform cross section which permit it to take heavy thrust loads in either direction in combination with radial loads without any impairment of operating efficiency or performance.

No appreciable bearing wear occurs with the result that noise and the expense of bearing adjustments and replacements are avoided. Furthermore, the bearing is a self-contained unit which permits of the ready assembly of shafts and bearings in restructed locations.

Our engineers will gladly submit recommendations for applying ball bearings to clutches and other vital rotating automotive parts.

THE HESS-BRIGHT MANUFACTURING COMPANY

Supervised by SKF INDUSTRIES INC., 165 Broadway, New York City

955

Races displaced to show DEEP-GROOVE bearing carrying maximum end thrust in a forward direction.

Races displaced to show THE SAME bearing carrying maximum thrust in reverse direction.

BALL BEARINGS

The Highest Expression of the Bearing Principle

KELLY SPRINGFIELD AIRCORE

Why the Aircore Tire Should Not Be Overloaded

The Kelly Aircore double-cushion truck tire has been proved by tests to be practically as resilient as a properly inflated pneumatic—yet when properly applied and used, it will have longer life than the average of the solid type of truck tire.

There are certain conditions, however, which must be observed in order to obtain the best results from the Aircore and one of these is, that it *must not be overloaded.*

Owing to the fact that the Aircore is of the high profile type and its spearhead core allows considerable deflection under load, its capacity for a given base width is not as great as would be the case if it were a non-resilient solid rubber tire. It will be readily understood that excessive loads would create excessive deflection of this tire—a condition which, of course, is not conducive to long life.

The design of the center core has been carefully calculated to permit certain maximum loads on various sizes, and it is only when these load limits are carefully followed that the full resiliency, long life and certainty of service of the Aircore can be obtained.

The following table shows the maximum weights to which loads should be limited on Aircores of various sizes:

Size of Aircore	Maximum Weight
4 inches	1300 pounds
5 inches	1700 pounds
6 inches	2500 pounds
7 inches	3500 pounds
8 inches	4500 pounds
9 inches	5000 pounds
10 inches	6000 pounds

Kelly-Springfield Tire Co.
250 West 57th Street New York

Notes and Reviews

In this column are given brief items regarding technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

THE HIGH-COMPRESSION HIGH-SPEED ENGINE VERSUS THE LOW-COMPRESSION MODERATE-SPEED ENGINE FOR GENERAL USE IN MOTOR VEHICLES. By H. R. Ricardo and F. Strickland. Papers presented before the Institution of Automobile Engineers in *Engineering*, Nov. 17, 1922, p. 627.

The Institution of Automobile Engineers, recognizing that the advocacy of very high-compression high-speed gasoline engines is becoming increasingly common, organized a debate on this subject, which was held in London, on Nov. 8, 1922. The merits of the high-speed type were discussed by H. R. Ricardo, who based his argument mainly on the increased fuel economy to be secured by its use; the smaller and lighter pistons and reciprocating parts and the increased turbulence effected by smaller valves. Major F. Strickland, in supporting the claims of the low-compression moderate-speed engine, maintained that the improvement noted in the steam engine with an increase of speed was due to causes that do not obtain in the case of the internal-combustion engine, the parts of which on account of inertia forces, must be increased in size as the speed is increased, and that among the advantages of low compression and moderate speed are less piston and cylinder-wear, simplicity and certainty of operation of the lubricating system and freedom from noise.

AUTOMOBILE CHASSIS. By Ben G. Elliott. Published by McGraw-Hill Book Co., New York City. 233 pp.; 233 illustrations.

Professor Elliott's book is designed to serve as guide and reference book on all parts of the gasoline automobile except the powerplant and its immediate accessories and the body. Fundamental principles are emphasized and these are illustrated by many examples from modern practice. The construction, purpose, operation, adjustment and care of springs, axles, the steering-gear, clutches, transmissions, differentials, bearings, wheels and rims, tires, brakes and chassis lubrication are fully covered.

GRINDING: WHEELS, MACHINES, METHODS. Information on modern practice in the production and application of abrasives, grinding wheels and grinding machines, compiled by members of the executive and technical staffs of the Norton Co., Worcester, Mass., and published by the company, 375 pp.; numerous illustrations and tables.

This book deals in a very instructive manner with modern grinding practice. Examples of processes and machines have been selected chiefly with a view to showing the Norton grinding machines, but the work deals with practically every modern application of precision, semi-precision and hand-grinding.

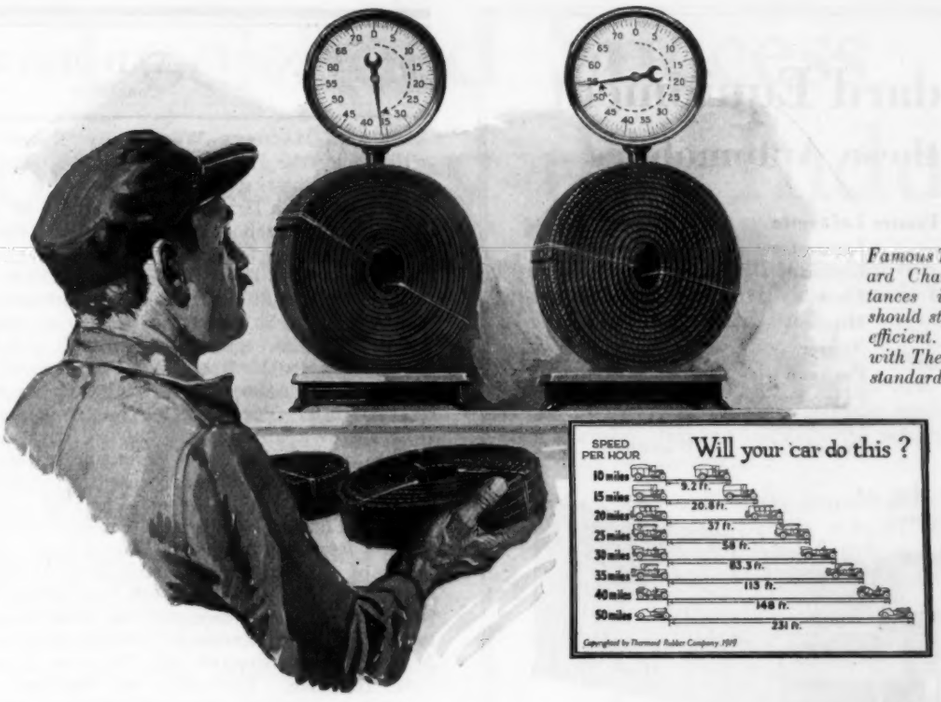
HIGHWAYS AND HIGHWAY TRANSPORTATION. By George R. Chatburn. Published by Thomas Y. Crowell Co., New York City. 463 pp.; many illustrations.

To quote the author's preface, this book is written "for those who desire a conversational knowledge of the origin, evolution and present status of highway transportation, even though it be glimpsed by a very rapid passage through a very large subject." For those who wish to make a more detailed study of the subject the author provides a selected list of references following each chapter.

AUTOMOBILE LABORATORY MANUAL. By Frederick F. Good. Published by McGraw-Hill Book Co., New York City. 174 pp.; 88 illustrations.

The purpose of this outline of experiments is to provide a progressive series of study units in three groups that will serve as a basis for the organization of laboratory automobile classes for beginners. The course covers a systematic introduction to the automobile mechanisms and a study of their fundamental principles and includes practical work and minor repairs.

(*Continued on p.* 12)



Famous Thermoid Standard Chart — shows distances in which cars should stop if brakes are efficient. Brakes lined with Thermoid meet these standards.

"At least 40% extra material"

The new Thermoid Brake Relining Machine. Cuts time 60%—does a better job than old hand methods. Price $15, $17.50 west of the Rocky Mountains. $25 outside of U. S.
Write for special offer to Thermoid dealers.

A simple test which shows the 40% more material in Thermoid Brake Lining

A roll of Thermoid Brake Lining—100 feet—was weighed. The indicator registered 54 pounds, 8 ounces. Then one after another, the rolls of four other leading manufacturers were put on the scales.

Thermoid outweighed each by over 40%!

This means that the motorist gets more for his money in Thermoid than in any other lining. He gets longer wear—by about 40%—and a sure, *even* gripping surface until Thermoid is worn wafer-thin.

Most of the "give" is taken out of Thermoid before it leaves the factory—and *40% more material* is put in its place!

Thermoid *wears* down instead of *mashing* down—it doesn't "grab" or slip. Thermoid gives constant gripping power till worn wafer-thin.

Standard equipment on 50 leading cars

Because of its unfailing, its recognized supremacy and longer life, 50 manufacturers of leading cars in America now install Thermoid Brake Lining as standard equipment.

Send for our booklet, "The Dangers of Faulty Brakes." It contains valuable information and complete records of brake lining tests which every engineer will be glad to have on hand.

THERMOID RUBBER COMPANY
Factory and Main Offices: Trenton, N. J.

New York Chicago Los Angeles Detroit Atlanta
San Francisco Boston Cleveland Kansas City
Seattle London Paris Turin

Thermoid Brake Lining

Hydraulic Compressed

Makers of "Thermoid-Hardy Universal Joints" and "Thermoid Crolide Compound Tires"

Standard Equipment
on these Automobiles

American-La France	Lafayette	Roberts
Bay State	Lancaster	Rolls-Royce
Bell	Leyland	Stevens-Duryea
Case	Lincoln	Straker-Squires
Cadillac	Mitchell	Twin City
Climax	Napier	U. S. Tractor
Columbia	Packard	Vulcan Truck
Cunningham	Paige-Detroit	Ward-La France
Kissel-Kar	Pierce-Arrow	Westcott
	Premier	Wisconsin

Cut open view of regulator

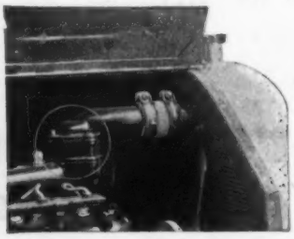
Keeps the motor at the degree of highest efficiency

Consists of three main parts: the Sylphon—that seamless, solderless, flexible, all-metal expansion member, which is the heart of all Sylphon products; a valve and a housing for the Sylphon. The Sylphon is filled with a highly volatile liquid, which vaporizes at a predetermined temperature, expanding the Sylphon and opening the valve to admit water and contracting and closing the valve when the temperature falls. It is self-regulating, adapted to pump or thermo-syphon cooling systems, can be installed between the radiator and the engine, either in outlet or inlet water connection. Has no moving parts to wear out, needs no oiling and will outlast the motor. Do not accept imitations or substitutes.

Send for Bulletin JUR

THE FULTON COMPANY
KNOXVILLE, TENNESSEE
New York Chicago Detroit Philadelphia
Representatives in all principal cities

As Installed on Kissel-Kar



As installed on Pierce-Arrow

NOTES AND REVIEWS
Continued

ADVANCED MACHINE WORK. By Robert H. Smith. Published by the Industrial Education Book Co., Boston. 744 pp.; 823 illustrations.

This textbook is a practical manual of machine-shop practice for shops, schools and individuals that has already won for itself a large following in colleges, universities and technical schools, this being the seventh edition. The new section 15 gives practical instruction in making mechanical measurement with light waves to the ten thousandth, hundred thousandth and even to the millionth of an inch.

SEVENTH ANNUAL REPORT OF THE NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS, including Technical Reports Nos. 111 to 132. Published by the Government Printing Office, City of Washington.

The progress made in scientific research in aeronautics during the year 1921 is described in the reports of the technical subcommittees and exemplified by the technical reports, published during that period, copies of which are summarized in this Report. Attention is especially invited to the Summary of General Recommendations of the Committee, preceding the body of the Report, and setting forth what, in the judgment of the Committee, the most important steps to be taken for the advancement of aeronautics.

A STUDY OF SIDEDRAFT AND TRACTOR HITCHES. By Arthur H. Hoffman. University of California Agricultural Experiment Station. Bulletin No. 349. Published by the University, Berkeley, Cal.

This bulletin was prepared to enable the author to answer in as complete a manner as possible the numerous requests made by farmers for information on various phases of tractor hitching. The application of mechanical principles to agricultural implements is clearly explained and photographic illustrations accompany the text. A valuable list of references to scientific articles and trade publications is included.

PREPARATION OF LIGHT ALUMINUM-COPPER CASTING ALLOYS. By R. J. Anderson. Bureau of Mines Technical Paper No. 287. Published by Government Printing Office, City of Washington.

The author says in his introduction: "In the United States the consensus of opinion among foundrymen is that the alloy containing 92 per cent of aluminum and 8 per cent of copper is the best alloy available for general casting purposes and for some special castings. In addition, more or less definite light alloys have been developed for particular uses, notably piston and carbureter alloys and alloys for so-called leak-proof parts." The process of manufacture of this alloy is described as well as the methods used in preparing various alloys. Twenty-two pages are devoted to description of a number of interesting experiments made in the preparation of rich alloys, and a short list of publications available for free distribution to those interested in aluminum and its alloys follows.

PRINCIPLES OF VEHICLE SUSPENSION. By H. S. Rowell. Published in *The Automobile Engineer*, April, 1923, p. 118.

Abstract of paper read before the Institution of Automobile Engineers.

FURTHER ALCOHOL FUEL DEVELOPMENTS. Published in *Motor Cycling*, London, April 18, 1923, p. 772.

This short article describes the special fuel, Ricardo-Discol, patented by H. R. Ricardo, which is to be placed on the market in England shortly at 6 shillings per gal. At this price the new fuel is of little interest to the ordinary driver, at present, but further developments may remove the price barrier.

Ricardo-Discol is a mixture having an alcohol base. The exact composition cannot be stated, but the following typical example, taken from the patent specification, is near enough for all practical purposes:

Ethyl Alcohol, per cent	60
Acetone, per cent	20
Benzol, per cent	10
Water, per cent	10

(*Continued on p.* 14)

Lockheed Success Recognized by the Industry

Engineers and others whose business it is to keep informed on the trend of motor car development, recognize the success of Lockheed Hydraulic Four Wheel Brakes.

In this device they see the ultimate in brake application—a highly and continuously efficient brake for each wheel, simple in design, rugged in construction, which obviates, once and for all, the necessity of frequent readjustment heretofore experienced.

During the last five years Lockheed Hydraulic Four Wheel Brakes have had the most complete and rigorous test of all, under every conceivable condition.

This is their use by approximately 1000 motor car owners.

Some of the cars on which Lockheed Hydraulic Four Wheel Brakes are used have covered more than 50,000 miles.

Most of these brakes have been, and are being, used in mountainous regions, where they have given the most amazing results.

A Leading Feature on 1924 Models

It is obvious, of course, that the sudden spontaneous demand,—such as that which occurred when the self-starter first sprang into public favor—will place those manufacturers who early decide upon this new equipment, in a position of production advantage.

The fact that 12 manufacturers have sought the close co-operation of the Hydraulic Brake Company, and are now purposing the use of these brakes, is intensely significant.

Four wheel brakes will be one of the chief, and probably *the* chief, new chassis feature of 1924 production.

There are two reasons for this. One is the fact that present brake systems are recognized as inadequate, particularly under the more severe driving conditions which now confront the motorist.

Another, and extremely important reason, is the stiffer competition which strongly brings out the sales value of such equipment as Lockheed Hydraulic Four Wheel Brakes.

A New Experience for the Motorist

It has been demonstrated time after time, and over and over again, that Lockheed brakes make a motor car much easier to sell. They become, in fact, the main feature of a demonstration, and one of the principal selling points.

The ease and smoothness with which Lockheed Four Wheel Brakes operate; the quickness with which they can stop a car when necessary; the feeling of far greater security which they give to the driver, all supply new and distinct advantages to the motorist.

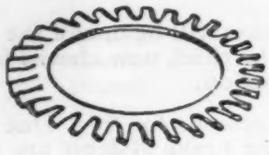
The potential demand for Lockheed Four Wheel Brakes is clearly indicated by the fact that on a motor car where their special installation caused a substantial increase in price, the Lockheed equipped cars sold 100% faster than the non-equipped cars.

We invite inquiries.

Hydraulic Brake Company
700 Harper Ave. Detroit, Michigan

LOCKHEED
Hydraulic Four Wheel Brakes

It's the Engineer's job to make the car BETTER



Few startling changes occur in automobile construction these days, but every progressive manufacturer is constantly on the lookout for minor improvements that will better his product.

Loosened nuts result in body noises; lost bolts or nuts hasten wear. Shakeproof lock washers are a distinct improvement. Vibration makes them lock tighter.

See Those Locking Struts

From 12 to 30 locking struts set at an angle of 45° immediately engage surfaces top and bottom under vibration, gripping in such a way as to give positive locking. Shakeproof are lighter and stronger than ordinary washers; they exert an even pressure at all points; they do not tend to distort thread; they can be used with shorter bolts; they are easier to handle (cutting labor cost); they do not rust.

From 200 to 500 lock washers are used in auto construction. Insure firm "close knit" construction by standardizing on Shakeproof.

SHAKEPROOF
Screw & Nut Lock Co.
Wrigley Building
Chicago

NOTES AND REVIEWS

Continued

It has been tested on the bench and also in racing work and is said to have proved suitable in all respects.

HIGHWAYS GREEN BOOK. Published by the American Automobile Association, City of Washington. 427 pp.; illustrated with photographs.

The object of the Highways Green Book, of which the 1922 edition is the third, is to combine in one volume a compendium of the outstanding highway activities of the past year and a forecast of the future. The book should be of great value to students of current highway legislation, economics, taxation, progress, construction and maintenance and transportation. Chapters dealing with highway research and highway engineering and transport education are ably treated by recognized highway authorities. Valuable lists of references, of highway organizations, and of county highway bond issues are given in appendices.

SOME REMARKS ON THE SUSPENSION OF VEHICLES. By P. Lemaire. Published in *La Technique Moderne*, April 15, 1923, p. 241.

A mathematical study of suspension problems with special reference to riding comfort.

REVUE GENERALE DE L'AERONAUTIQUE. Published by Librairie Aeronautique, Etienne Chiron, Paris, quarterly. 256 pp.; many figures.

This volume, Vol. 2, contains the following articles of interest to members:

(1) The General Problem of the Airplane. P. and M. Richard. 56 pp.
(2) The Use of Reduction Gears on Aircraft Engines. Capt. G. Lehr. 34 pp.
(3) Use of Wood in Aircraft Construction. (Continued from Vol. 1.) Marcel Monin. 12 pp.
(4) The Development of Gliders. Captain Roca. 11 pp.

THE NORTH-LUCAS LIGHT CAR. By O. D. North. Published in *The Automobile Engineer*, April, 1923, p. 98.

A critical examination of a novel and original design, having the engine located at the rear; a design conspicuous for its good suspension, absence of engine vibration and reduced wind-resistance.

THE EVALUATION OF NOISE. Published in *The Automobile Engineer*, April, 1923, p. 109.

A method of comparing and expressing sound in Unit Terms.

METALLURGY AS APPLIED TO ENGINEERING PRODUCTION. By W. R. Franklin. Published in *Engineering Production*, May, 1923, p. 256.

MICROSTRUCTURE OF PAINT FILMS. By Harold L. Maxwell. Published in *Chemical and Metallurgical Engineering*, May 14, 1923, p. 850.

An attempt to determine the relation between microstructure and protective value of certain paints and pigments.

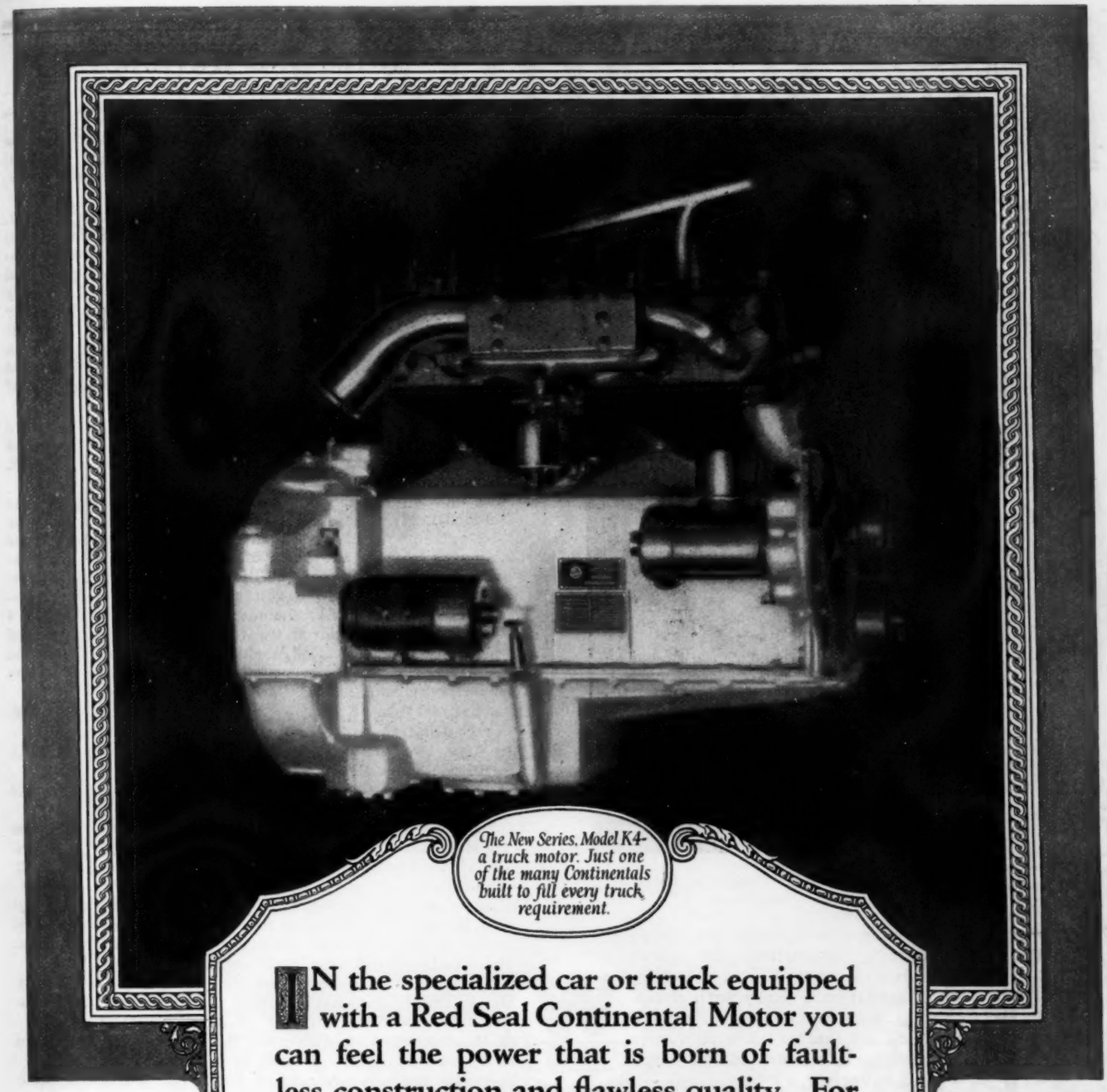
ALUMINUM BRONZE AS AN ENGINEERING MATERIAL. By W. M. Corse. Published in *Mechanical Engineering*, May, 1923, p. 283; 5 figures.

ALUMINUM BRONZE AS AN ENGINEERING MATERIAL. Published in *Chemical and Metallurgical Engineering*, May 14, 1923, p. 863.

THE ENGINEERING INDEX FOR 1922. Published annually by the American Society of Mechanical Engineers, New York City.

Some 1300 periodicals, reports and other publications regularly received during the year by the Engineering Societies' Library have been reviewed and from over 600 of these the articles to be indexed have been selected. The items are unusually concise and the number is considerably larger than heretofore. Frequent users of the index will find that the classification and the system of cross-indexing have been improved. The extended list of references to bibliographies is an instance of the attention that has been given to details.

(*Concluded on p.* 16)



The New Series, Model K4- a truck motor. Just one of the many Continentals built to fill every truck requirement.

IN the specialized car or truck equipped with a Red Seal Continental Motor you can feel the power that is born of faultless construction and flawless quality. For twenty-two years such perfection has been represented by—the Continental Red Seal.

Built by the largest motor Specialists in the world

CONTINENTAL MOTORS CORPORATION
Detroit and Muskegon, Michigan

CONTINENTAL MOTORS
Powerful as the Nation
AMERICA'S STANDARD

DOEHLER
The World's Largest Producer of
DIE-CASTINGS

Doehler Die-Cast Aluminum Carburetor Connection

Where die-castings are to be plated, enamelled, or given other special finish, Doehler engineers are ready with chemical and metallurgical experience invaluable to a customer because of its unequalled scope and diversity.

To produce die-castings that are right is but part of the Doehler policy.

The Doehler Company feels equally obligated to give to its customers every assistance in using those die-castings to best advantage, that the utmost on the investment may be realized.

DOEHLER DIE-CASTING CO.
BROOKLYN. N.Y.
TOLEDO. OHIO.

NOTES AND REVIEWS

Concluded

BIBLIOGRAPHY OF AERONAUTICS. 1917-1919. Compiled for the National Advisory Committee for Aeronautics by Paul Brockett. Published by the Government Printing Office, City of Washington.

This work covers the literature published from Jan. 1, 1917, to Dec. 31, 1919, and continues the work of the Smithsonian Institution issued as Vol. 55 of the Smithsonian Miscellaneous Collections, which covered the material published prior to June 30, 1909, and the work of the National Advisory Committee for Aeronautics as published in the Bibliography of Aeronautics for the years 1909 to 1916. The National Advisory Committee for Aeronautics will next present a bibliography for the years 1920 and 1921 in one volume, and it is the Committee's intention to publish a Bibliography of Aeronautics annually thereafter.

FATIGUE IN METALS. By C. F. Jenkin. Paper read before the Royal Aeronautical Society, Dec. 7, 1922. Published in *Chemical and Metallurgical Engineering*, May 7, 1923, p. 811.

The author demonstrated the theory of fatigue by the use of a model. It was found that the results predicted by the model agreed with the test data. The author proposes to use this model to form the basis of accurate strength calculations and to introduce fatigue limits into steel specifications.

AIRCRAFT DEVELOPMENT SINCE THE ARMISTICE. Part 1—Airplanes; Part 2—Armament; Part 3—Engines; Part 4—Equipment. Prepared by the engineering division of the Air Service, McCook Field, Dayton, Ohio. Published as Air Service Information Circular No. 402 by the Government Printing Office, City of Washington.

THE STEAM WAGON FROM THE DESIGNER'S POINT OF VIEW. By F. J. Bretherton. 28 pp.; 25 illustrations.

THE USE AND LIMITATIONS OF THE STEAM WAGON. By C. Le M. Gosselin. 17 pp.; 11 illustrations.

Two reprints published by the Institution of Automobile Engineers, April, 1923.

TESTING THE QUALITY OF LUBRICATING OILS. By Winslow H. Herschel. Published in the *Proceedings of the Engineers' Society of Western Pennsylvania*, January, 1923, p. 503.

VISCOSITY OF LUBRICATING OILS AT HIGH PRESSURES. Progress Report of the Special Research Committee on Lubrication of the American Society of Mechanical Engineers. Published in *Mechanical Engineering*, May, 1923, p. 315.

EXPERIMENTS WITH FABRICS FOR COVERING AIRPLANE WINGS. By A. Pröll. National Advisory Committee for Aeronautics Technical Note No. 137. 37 pp.; 33 illustrations.

THE MEASUREMENT OF AIRFLOW. By R. O. King. Published in *Engineering*, April 13 and April 20, 1923.

Discusses the measurement of airflow by a throttle plate with special reference to the measurement of the air supply to internal-combustion engines.

MONEL METAL. By John Arnott. Published in *Engineering*, April 20, 1923, p. 495.

SOME NOTES ON THE DESIGN, CONSTRUCTION AND OPERATION OF FLYING BOATS. By Major J. D. Rennie. Published in the *Journal of the Royal Aeronautical Society*, April, 1923, p. 123.

WIRELESS IGNITION. Verbatim copy of the patents taken out by Robert Bosch. Published in *La Pratique Automobile*, April 1, 1923, p. 9348.

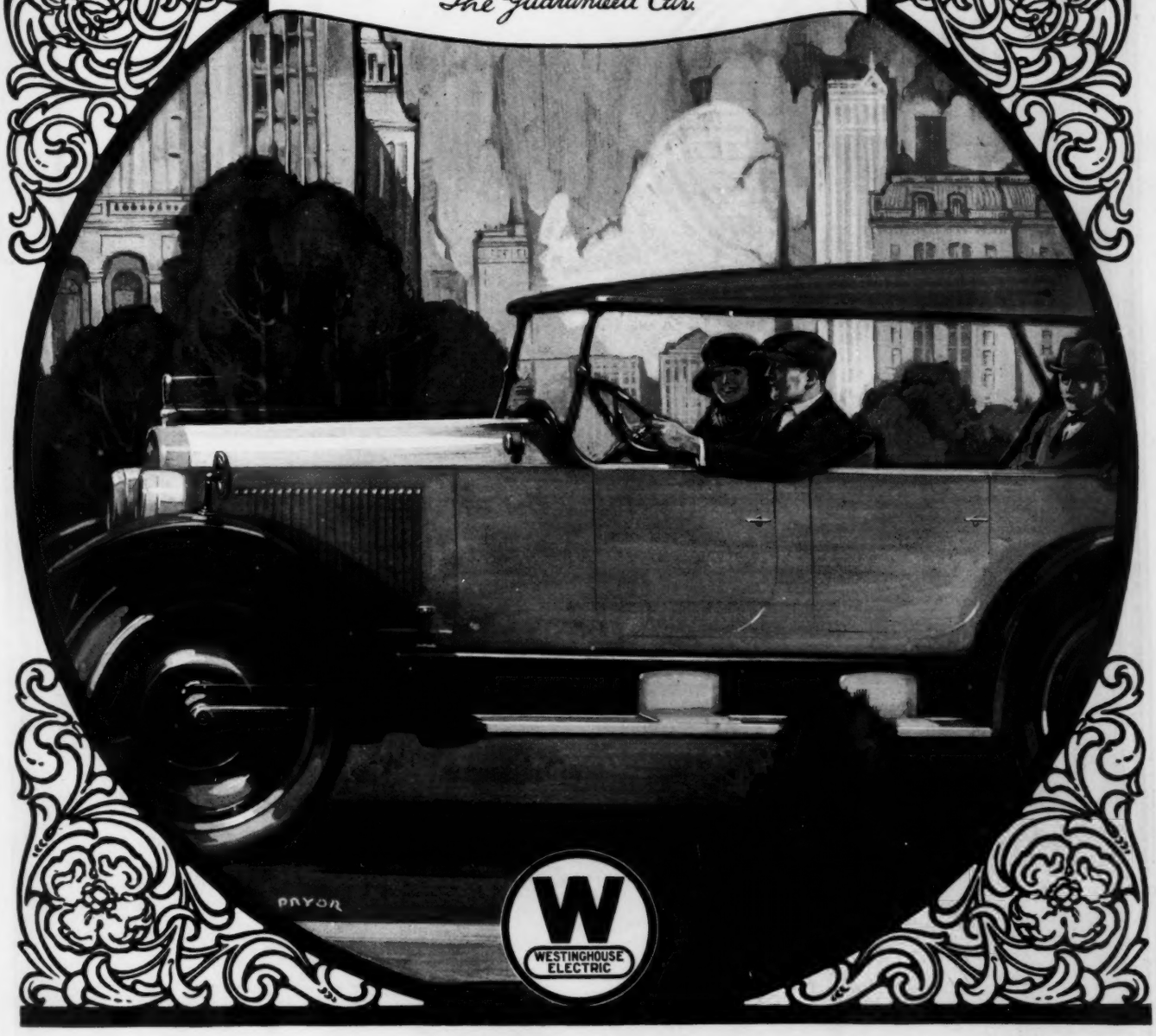
TESTING MACHINE DEVELOPED TO SOLVE GEAR-STRENGTH PROBLEM. By Wilfred Lewis. Published in *Automotive Industries*, May 3, 1923, p. 974.

RECENT DEVELOPMENTS IN AIRCRAFT ENGINES IN THE NAVY. By Bruce G. Leighton. Published in *Aerial Age*, May, 1923, p. 220.

NEW LONG-LIFE MOLD DEVELOPMENT. By Dr. Richard Moldenke. Paper presented at the annual meeting of the American Foundrymen's Association. Published in *The Iron Age*, May 3, 1923, p. 1251.

GARDNER

The Guaranteed Car



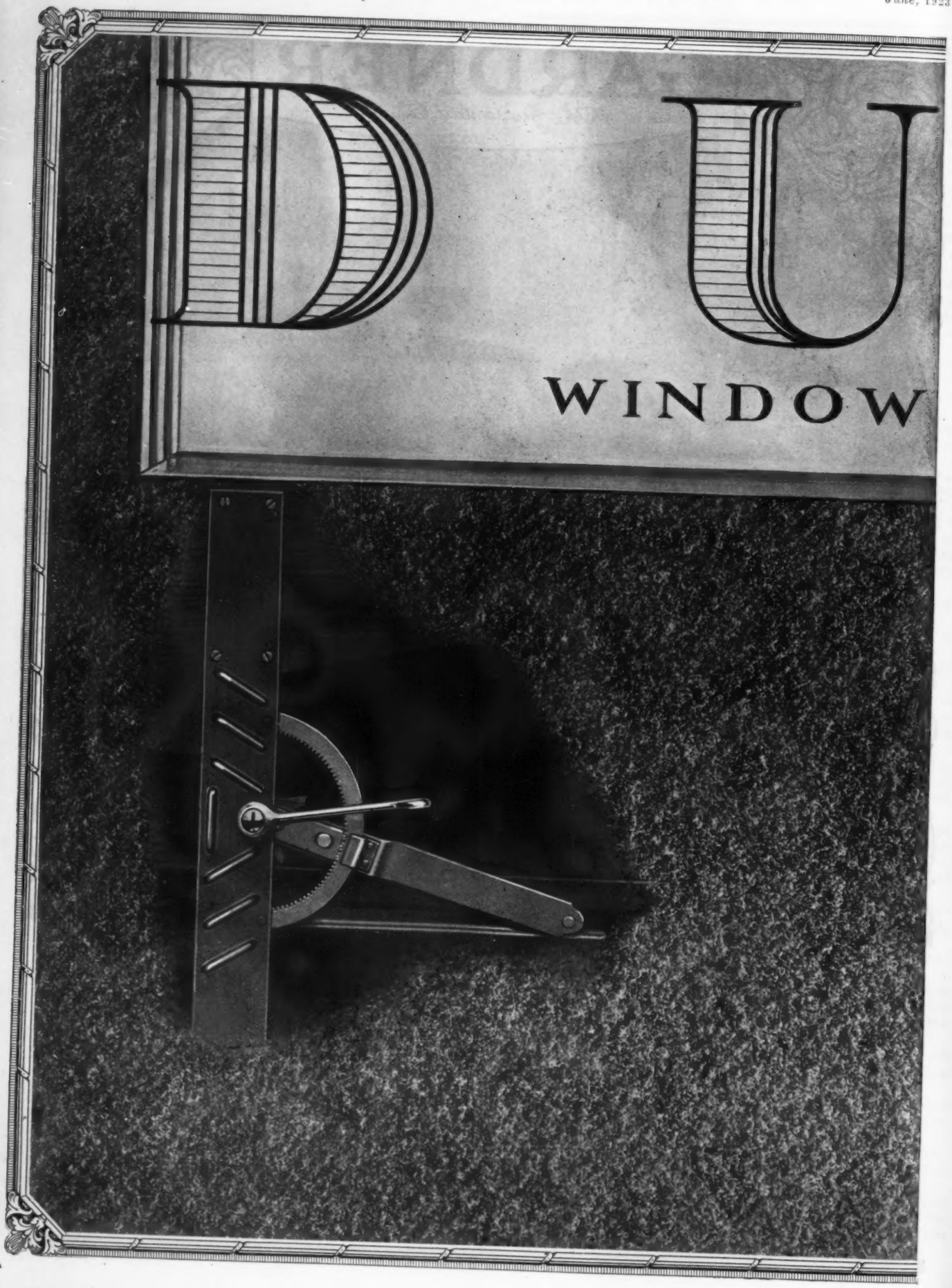
THE faith of the Gardner Motor Company in its product speaks in the full *one-year written guarantee* accompanying every Gardner sold—a guarantee backed by an organization of 40 years standing.

Besides the Gardner, Westinghouse Starting, Lighting and Ignition Equipment is the choice of a large number of car builders who do not choose materials for their cars because of low purchase price. *Like Gardner,* their selections are guided by the reliability of the supplier and the ability of the apparatus to function properly when built into the automobile for which especially designed.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

Automotive Equipment Department, Sales and Service Headquarters: 82 Worthington St., Springfield, Mass.

Westinghouse


WINDOW

RA

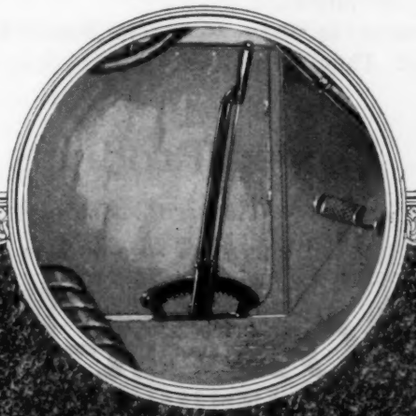
REGULATORS

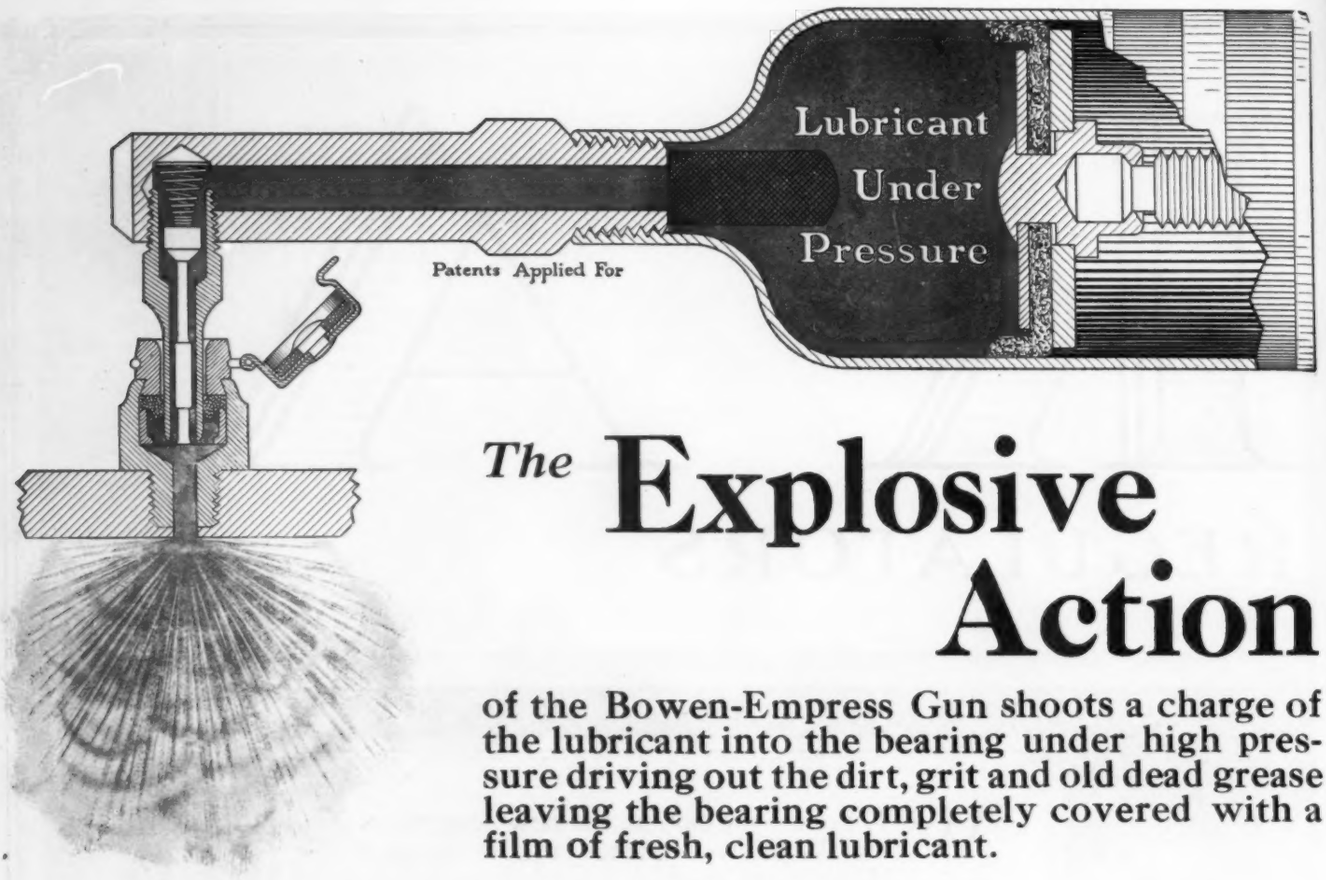
WITH one swift motion, the new lever type of Dura Window Regulator raises or lowers the glass and locks in any position as securely as the brake on your car.

Dura alone has developed the lever action window regulator, and this new regulator represents the utmost convenience which our entire experience has taught.

Installed on the face of the door instead of the pillar, the new Dura lifter has no rights or lefts. It weighs only three pounds and a quarter, including the handle. In operation it is as perfect as the motion of your arm.

The DURA COMPANY, *Toledo, Ohio*





The Explosive Action

of the Bowen-Empress Gun shoots a charge of the lubricant into the bearing under high pressure driving out the dirt, grit and old dead grease leaving the bearing completely covered with a film of fresh, clean lubricant.

Before applying the Bowen-Empress Gun to the fitting on the bearing, pressure is first developed in the gun by turning the plunger forcibly against the lubricant. A check valve in the nozzle holds the pressure within.

Next, using one hand only the connection cover is lifted with the slotted gun end and the nozzle thrust into the connection, the valve in the nozzle coming in contact with the trip in the bottom of the connection releasing the pressure and instantaneously flooding the bearing with a charge of the lubricant. The dust tight connection cover is then snapped shut using the gun end. Then withdraw the gun and develop the pressure for the next bearing.

Quick, Clean and Convenient. No connections to make between gun and fitting. No easily mislaid dust caps to remove and replace. No dirt collecting open ball check fittings. No flexible hose to break under pressure. Unnecessary to lock gun to fitting on bearing or to turn back plunger to relieve pressure before removing gun from fitting on bearing.

The Bowen-Empress System can be used with either oil or grease as the lubricant.

One Hand Operates It

Bowen Products Corporation

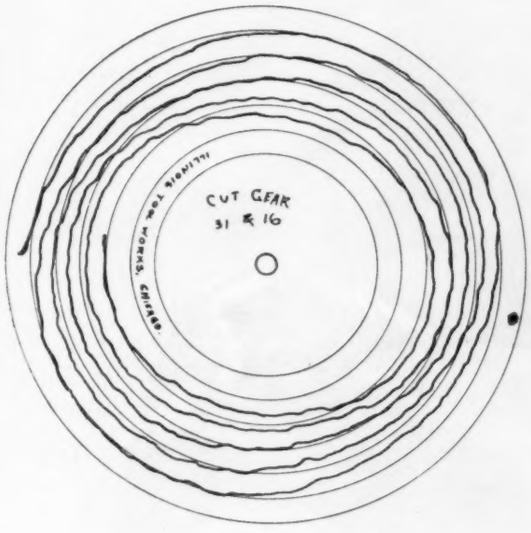
Auburn Division, Auburn, N. Y.

Write for Descriptive Booklet—No. N-301

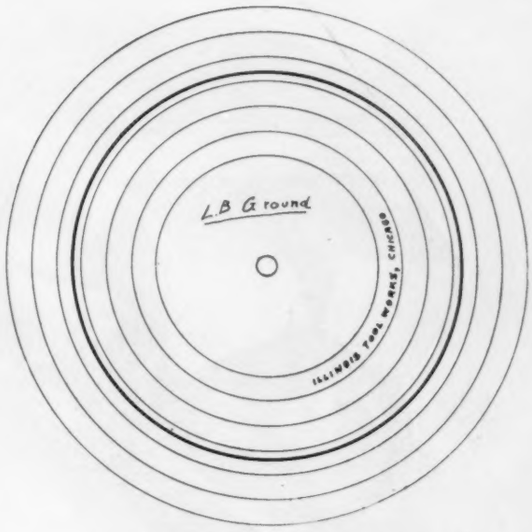
Bowen-Empress

HIGH PRESSURE LUBRICATING SYSTEM

FOR ALL MOTOR CARS AND TRUCKS



Test of Cut Gear



Test of L-B Ground Gear

Sound Waves Eliminated by Lees-Bradner Gear Grinder

The charts reproduced above were made on a velocity ratio testing machine at the Cadillac factory—waves in the line represent variations in angular velocity of the gear under test.

These waves make gear noise, cause excessive wear on gear teeth, destroy efficiency and produce destructive vibration. L-B Grinding of gear teeth corrects these errors whether caused by tooth form or spacing.

"These are the only perfect gears I ever saw," said the man who sells the velocity testing machine. They are so near to absolute perfection that we have found it necessary to construct a new type of testing machine—one which will measure a tenth of a thousandth of variation in tooth form or spacing. Ask for information about the Lees-Bradner Gear Tester.

With years of development, three years of production test in the hands of users, and ten times as many gear grinders in daily service as have been shipped by all competitors combined, we are offering a practical production machine. The Lees-Bradner Gear Grinder is protected by broad patents and users are protected by our long experience.

The LEES-BRADNER CO., Cleveland, Ohio, U. S. A.

A good bearing
It is not difficult to make a ball bearing. But a good bearing is a distinct achievement. The Schatz Universal Annular Ball Bearing embodies exclusive features of design and the highest manufacturing practice.
Specify the bearing with a margin of safety—Schatz Universal.
The Federal Bearings Co., Inc.
Poughkeepsie, N. Y.
Schatz
"UNIVERSAL"
Registered U.S.Pat.Off
Annular
BALL BEARING

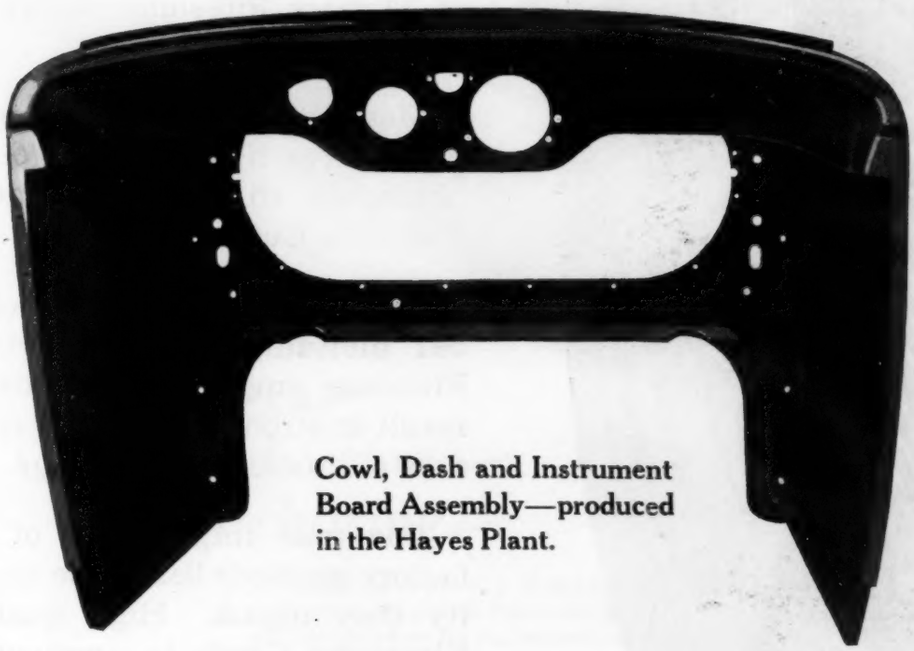
You See

Every Day

HAYES MFG. CO. HAYES DETROIT, MICH.

Every-where

Sheet Metal Products



Cowl, Dash and Instrument Board Assembly—produced in the Hayes Plant.

HAYES Manufacturing Company specializes in the production of Automobile Body Stampings.

Its whole equipment is planned for the rapid, economical production of automobile body parts that, because of their accuracy, lend themselves to rapid, uninterrupted assembly.

Hayes designs and builds its own dies—and the Company has a reputation for meeting specifications to a nicety.

Send us your blue prints for Body Stampings, Fenders, Hoods and other Standard or Special Sheet Metal Parts. Estimates furnished promptly.

Hayes Manufacturing Company

DETROIT, MICH.

An Important Factor in Automobile Value

FIRESTONE Gum-Dipped Cords add to the value—the appearance, the economy and the life—of any car.

Carefully developed over a period of 22 years, Firestone quality is today at the peak.

Many special manufacturing processes have been worked out and perfected in the betterment of Firestone Cords.

Gum-Dipping, air-bag cure, rubber blending and tempering, as Firestone employs these processes, result in stronger, yet more resilient tires of much longer mileage.

The true importance of these factory methods lies in the uniformity they insure. High quality in Firestone Cords is unvarying in hundreds of thousands of tires.

Most Miles per Dollar

The Mark of Quality

Firestone

BASCO

Approved

Sales
Production
Purchasing

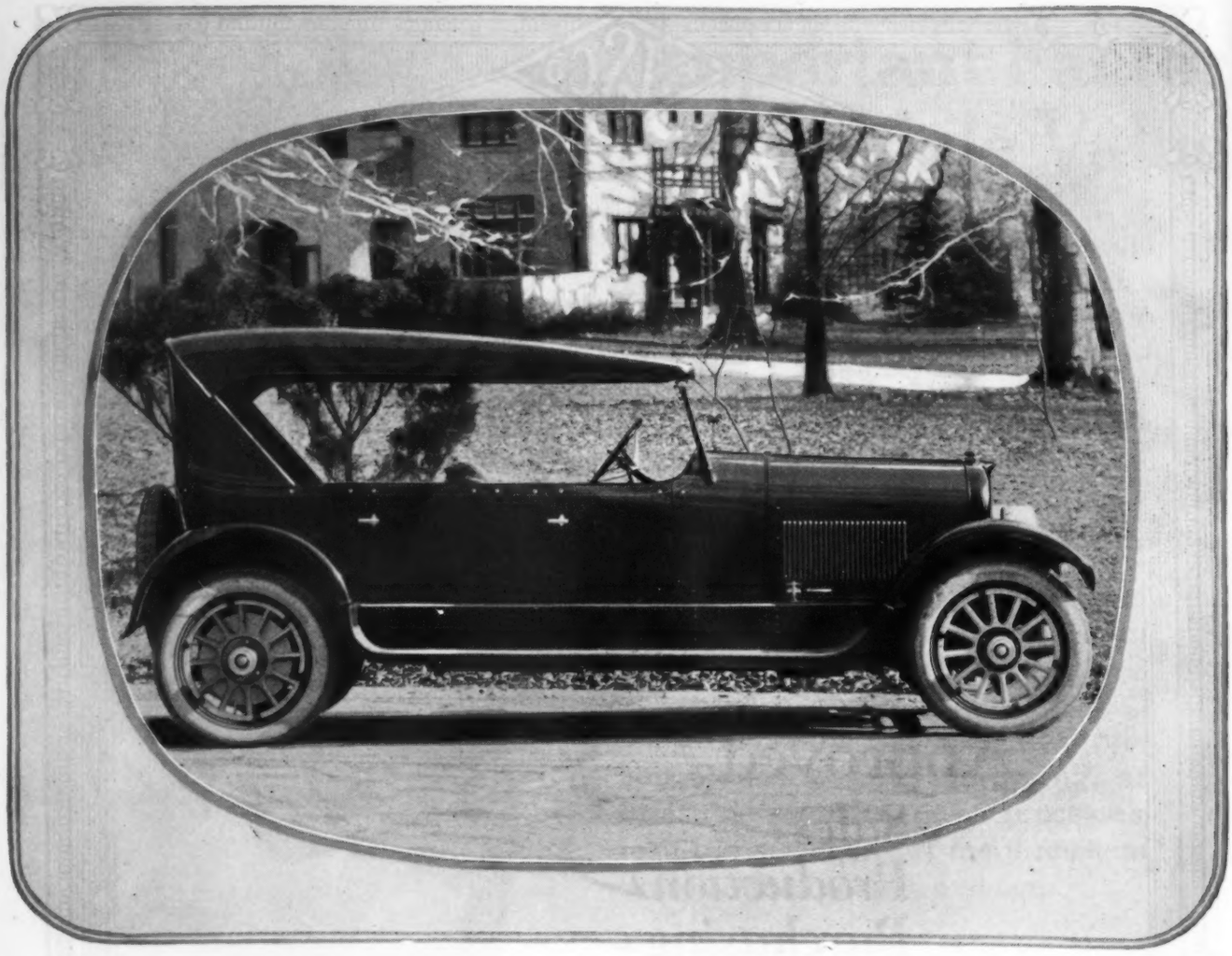
THE stamp of approval! Years of serving the automotive industry have placed Basco body hardware and electrical components on *the majority* of American cars and trucks. A splendid tribute to twelve years of service.

We are proud of it. We believe it proves that Briggs and Stratton have the comprehension and vision to grasp the desires of engineering, production and purchasing departments, and fuse them into a finished product! Briggs and Stratton does that for other leaders of the industry—and can do it for you.

Lighting, Ignition and Starting Switches, Instrument Panels, Generator Cutouts, Horns, Body Hardware including Locking and Non-Locking Outside Handles, Inside Levers and Knobs, Door Locks and Hinges, Tool Box, Pillar, Deck and Compartment Locks. The new Basco catalog is ready for mailing to Automobile, Truck and Body Builders.

Briggs & Stratton Co.
Milwaukee Wisconsin

BASCO



Thoroughbred

NEVERLEEK adds the touch of elegance that distinguishes fine cars. It marks the thoroughbred. For years it has been the standard top material of the leading automobile manufacturers and custom-body builders. Each year brings increased recognition of its pre-eminence.

Its beautiful surface reveals style and smartness; rugged endurance is built into the texture. Neverleek holds its cut and fit throughout the life of the car, and maintains its original lustre and trimness under severest conditions. Blistering sun cannot fade it or crack it. Heavy wet snow cannot make it sag or stretch.

Neverleek samples in different grains and with many styles of linings, with prices, will be sent to automobile manufacturers and top and body makers upon request.

NEVERLEEK
TOP MATERIAL
Trade Mark Reg. U. S. Pat. Off.

F. S. CARR COMPANY, 31 Beach Street, Boston, Mass. ***Branch Offices,*** **Detroit, St. Louis, Atlanta**

Bronze Piston Rings Greatly Reduce Cylinder Wear and Piston-Groove Wear and Reduce Ring Friction to a Minimum

AN ANNOUNCEMENT TO AUTOMOTIVE ENGINEERS

BY THE REUS MANUFACTURING CO., BALTIMORE, MD.

EXPERIMENTS that have been made by Automotive Engineers with unusual frequency since the earliest days of the automobile industry, covering many changes in the proportion and design, indicate the importance attached to piston rings.

To attempt to enumerate the changes that have been made in piston rings would be impossible because many which never extended beyond the experimental stage have been lost sight of; while of those that have remained, few represent marked progress.

Piston rings are vital to motor efficiency. The functions of piston rings are many-fold. Upon piston rings depend the power generated by the motor, the economy of that power, effective combustion and life of the motor.

Since practically every part of the motor is a working part, being in constant motion and usually under high speed conditions, the profession has solved most of the problems associated therewith by selecting special metal in the various phases of manufacture.

This is illustrated in the case of wrist pin bushings, crankshaft bearings, valves, cylinders, gears, etc. Bearings, for instance, are made of the highest grade of bronze in order to overcome the friction and heat which produce wear. Valves are also made of special metal which withstands extreme heat without warping; while with pistons, gears and other working parts, metal insuring utmost efficiency likewise is used.

Adhering to this fundamental principle, the Reus Manufacturing Company, after several years of experiment in the making of piston rings, has perfected the REBCO BRONZE PISTON RING. Early in these experiments we recognized that bronze was the only metal that would meet the requirements, therefore our efforts were concentrated upon a method of manufacture that would enable us to produce an efficient bronze ring at a price warranting competition with commonplace cast iron rings.

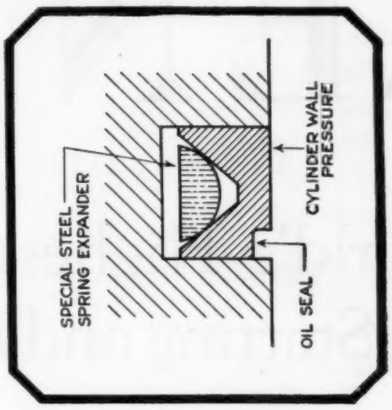
That our efforts have been successful is proved by the tests made under actual driving conditions and under most exacting circumstances. Further evidence of our successful achievement is contained in a statement made by a technical demonstrator of a well-known automobile at the recent New York Show, who in reply to a question as to the reason why the particular motor used only two rings instead of three rings on each piston, replied:

"One of the reasons why we made that change was to reduce friction on the cylinder walls, as the great amount of friction and wear created by the rings in a motor is being realized more and more. A BRONZE PISTON RING is on exhibition in this building for the first time, which to my mind seems to be a great step forward in reducing the friction and wear on the cylinder walls."

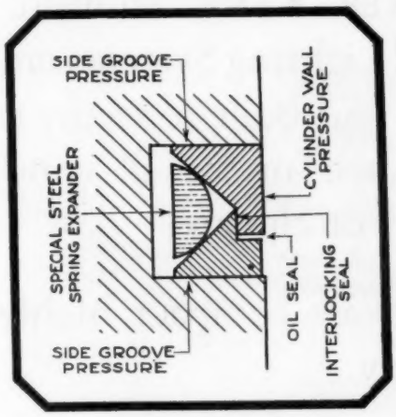
Tests which have been made prove that REBCO BRONZE PISTON RINGS in reducing the wear in a motor, naturally enhance the general efficiency and prolong the life of the most vital parts of a motor.

After very extensive road tests with REBCO BRONZE PISTON RINGS in a motor with 3¾-inch bore, the rings being ¼ inch in width, we found the following results: The motor being new, it was equipped with a complete set of twelve (12) BRONZE rings. After 3800 miles two of the rings were removed, the cylinders were accurately gauged and showed less than .0005-inch wear and the rings showed only the usual wear required to properly seat them.

The second inspection was made after the car had gone 7800 miles, when two more rings were removed and showed several thousandths of an inch wear; and when gauging the cylinders, we found them to show practically no wear beyond that shown on the first inspection. The third inspection was made after the car had been run 11,000 miles and results were practically the same.



Rebco Single



Rebco Dual

The final inspection was made after car had gone 19,800 miles and the cylinders were found to have about .001-inch wear and the grooves of the pistons were practically perfect. While the BRONZE rings showed more face wear than the conventional type, cast iron rings, the bronze rings were still good and in serviceable condition.

Admitting that a BRONZE ring will wear slightly more than a cast iron ring, nevertheless in the interest of motor efficiency it is easier and much cheaper to renew rings than to regrind cylinders, which also requires a complete set of oversize pistons and rings and considerable delay.

Another factor in favor of bronze as the ideal piston ring metal is that bronze, being a natural conductor of heat, passes heat off quickly.

The frictional resistance of REBCO BRONZE PISTON RINGS is considerably less than that of cast iron rings of the same width; and for this reason a wider ring may be used to distinct advantage, which also prolongs the life of the ring.

The spring tension of REBCO BRONZE PISTON RINGS is provided by means of a steel expander. The steel expander is made of chrome-vanadium nickel steel and will withstand any temperature in a motor under working conditions without the slightest possibility of losing any of its spring tension. The steel expander in the DUAL ring keeps the bronze members properly adjusted to the cylinder wall and both sides of the piston groove, thereby overcoming any possibility of the passing of oil. The steel expander in the SINGLE ring makes it function the same as any one-piece, conventional type, cast iron ring.

REBCO BRONZE PISTON RINGS have a low wall tension but are so designed that the tension can be increased or decreased to meet any special requirement, thus giving perfect control of wall tension.

In order that REBCO rings may be tried under every condition of motor performance, we will forward a set or sets to Automotive Engineers for their inspection and testing.

The features of REBCO BRONZE PISTON RINGS are PERFECT SERVICE—REASONABLE COST—and PROLONGED LIFE OF THE CYLINDER WALLS AND PISTON GROOVES.

ATWATER KENT

MAKERS OF

The World's Highest Grade Ignition, Starting and Lighting

ATWATER KENT Ignition, Starting and Lighting Systems are carefully designed and built to secure maximum performance under all conditions of operation or climate.

The units are compact, highly efficient and sturdy.

They will improve the performance of any motor and give long and satisfactory service.

ATWATER KENT MANUFACTURING COMPANY, PHILADELPHIA, PA.
4953 STENTON AVENUE

"33.8 Miles to the Gallon"

is the A. A. A. Coast to Coast record made by the "Gray"—it has Westinghouse ignition and Bakelite insulation.

Westinghouse

Gray

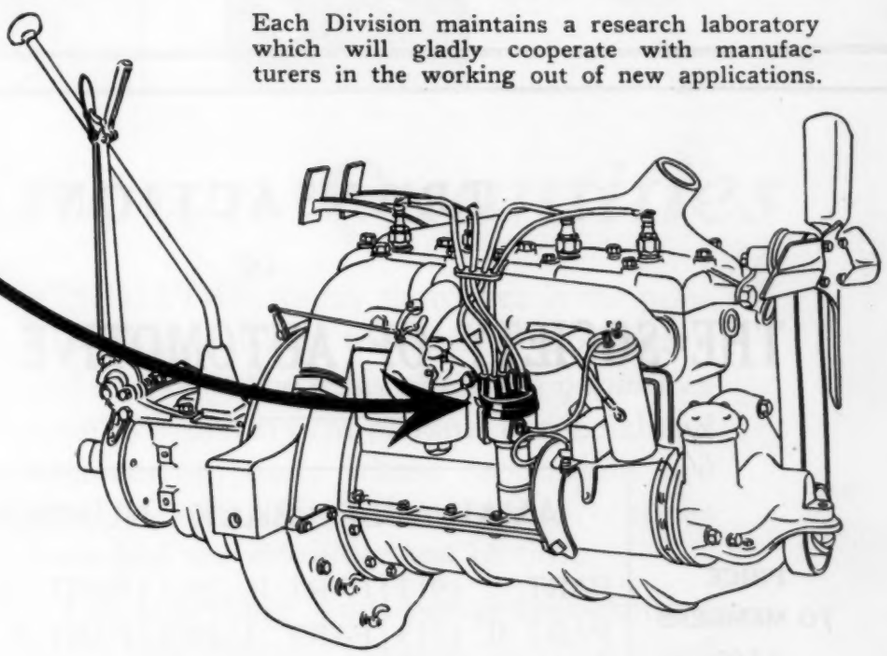
ONLY a molded insulation possessing a rare combination of essential properties may successfully be used for ignition distributor caps. Being set close to the motor it must resist high temperatures. It is essential that it be immune to injury from severe vibration and impervious to oil and moisture.

Since it meets all these requirements and is also noted for its high dielectric strength, molded phenol resin has become the universally accepted standard for ignition insulation. It is known by the trade-marks Bakelite—Condensite—Redmanol.

BAKELITE CORPORATION

Address the Divisions

Each Division maintains a research laboratory which will gladly cooperate with manufacturers in the working out of new applications.



Divisions of
BAKELITE CORPORATION

BAKELITE
General Bakelite Co.
8 West 40th St. New York

Condensite
Condensite Co. of America
Bloomfield, N. J.

REDMANOL
Redmanol Chemical Products Co.
636-678 West 22nd St.
Chicago, Ill.

The Material *of a* Thousand Uses

Have We Your Correct Address?

The New York Office is just as anxious as the individual members that they receive THE JOURNAL and other communications promptly.

This result cannot be achieved unless

Members notify the office whenever they make a change in their business connection or their mail address or both.

Members who have been in the service of the Government either as civilians or in the Army or Navy let us know when they leave the service and also when they re-enter commercial fields.

Your cooperation is necessary and will be greatly appreciated.

May We Have It?

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.

TRANSACTIONS
OF
THE SOCIETY OF AUTOMOTIVE ENGINEERS

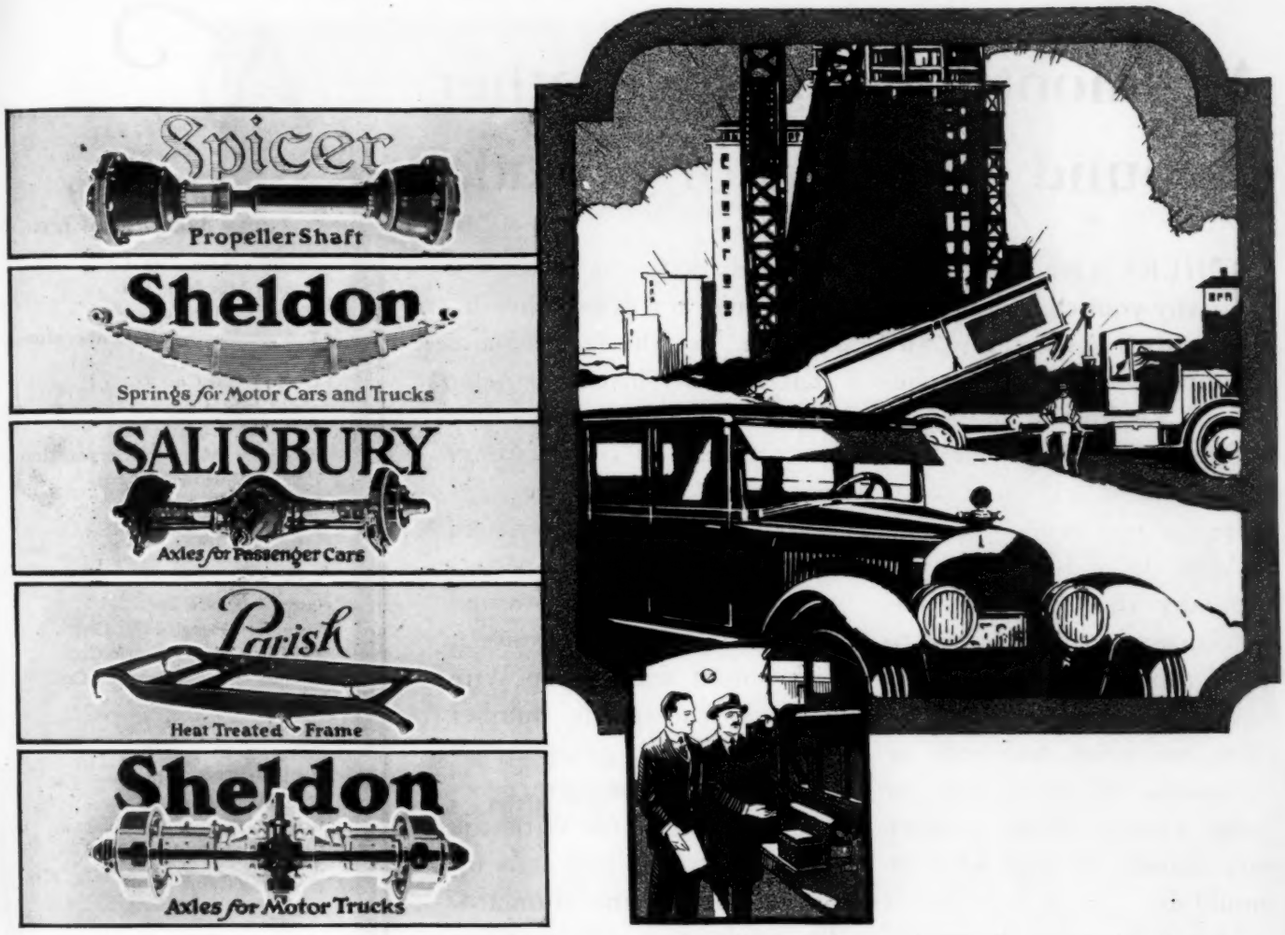
AVAILABLE BACK NUMBERS

PART I, 1913	PART II, 1917	PART I, 1920
PART II, 1913	PART I, 1918	PART II, 1920
PART I, 1914	PART II, 1918	PART I, 1921
PART I, 1915	PART I, 1919	
PART I, 1917	PART II, 1919	

PRICE TO MEMBERS $2.00 PER PART

PRICE TO NON-MEMBERS $10.00 PER PART

PLEASE ENCLOSE YOUR CHECK WITH YOUR ORDER



Known Quantities

GREATER to-day than ever is the public's tendency to select its motor cars and trucks on the basis of *known quantities*—units which are the product of specialized engineering; units whose reputations are established; units whose performances have had the infallible test of time.

Load-carrying and power-transmitting parts like Spicer, Sheldon, Salisbury and Parish make choosing easy.

Parish Mfg. Corp., Reading, Pa., and Detroit, Mich.
Sheldon Axle and Spring Co., Wilkes-Barre, Pa.
Salisbury Axle Company, Jamestown, N. Y.
Spicer Mfg. Corporation, South Plainfield, N. J.

C. A. DANA, *President*

As smoothly as grandmother wound a bobbin of thread

THERE is really no reason why your coils should not be wound as easily and smoothly as grandmother wound a bobbin of thread.

Simply see that your next specifications call for Acme Wire—*it goes in the space.*

Acme Wire is made by a company that for years has specialized in the endeavor to make a better wire for a particular purpose. In our own plant we wind hundreds of thousands of coils, and so know exactly what magnet wire should be and what it should do.

The difference between Acme Wire and other magnet wire is only a matter of degree. Probably with the naked eye you could not detect this difference. Yet the fact remains that in many instances Acme Wire has reduced winding costs as much as ten to twenty per cent.

Acme Wire is uniform and free from lumps and imperfections. It insures better-wound coils and fewer rejections. A coil wound with Acme Wire will take the specific number of turns without piling up.

Throughout the entire process of making Acme Wire it is inspected to see that it is up to the high Acme standard. The result is a quality product, one that we are proud to make and you will be glad to use.

Illustrated Catalog on Request to Engineers, Purchasing Agents, Executives and Operators.

THE ACME WIRE CO., New Haven, Conn.

NEW YORK CHICAGO CLEVELAND

Acme Wire

"It goes in the space"

Some Users of Acme Magnet Wire

Atwater Kent Mfg. Co.
Azor Motor Mfg. Co.
Century Electric Co.
Dayton Engineering Laboratories Co.
Delco-Light Co.
Diehl Mfg. Co.
Domestic Electric Co.
Eisemann Magneto Corporation
Electric Auto-Lite Corp.
Electric Specialty Co.
Electrical Products Mfg. Co.
Eureka Vacuum Cleaner Co.
Ford Motor Co.
Gray & Davis, Inc.
Hamilton Beach Mfg. Co.
Holtzer-Cabot Electric Co.
Hoover Suction Sweeper Co.
Klaxon Co.
Robbins & Myers Co.
Sangamo Electric Co.
Sunlight Elec. Mfg. Co.
U. S. Auto Supply Co.
Wagner Electric Corporation
Western Cartridge Co.
Westinghouse Elec. & Mfg. Co.

Acme Wire Products

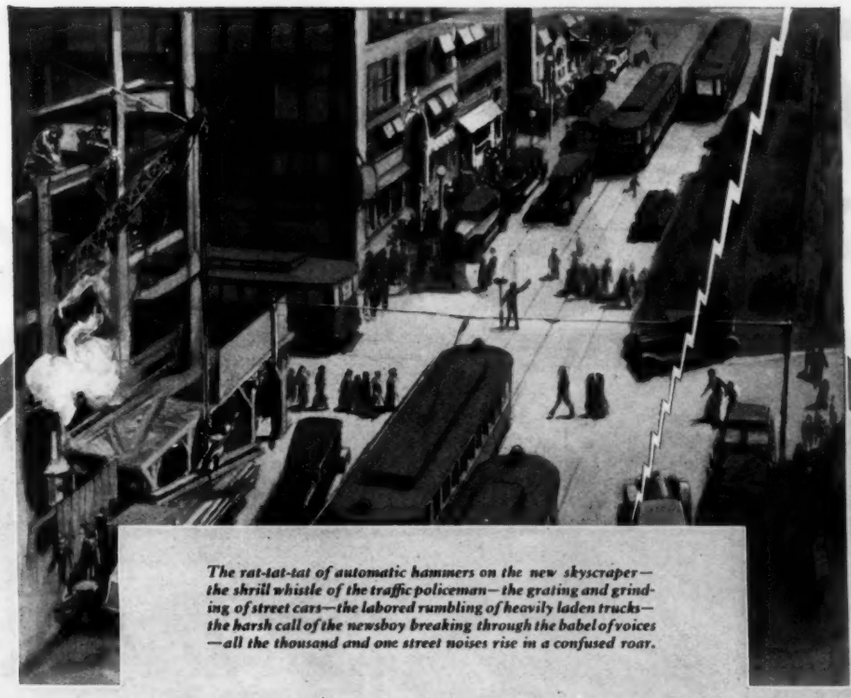
"Enamelite," plain enameled Magnet Wire; "Cottonite," Cotton-covered Enamelite; "Silkenite," Silk-covered Enamelite; Single and Double Cotton Magnet Wire; Single and Double Silk Magnet Wire. We also have a complete organization for the winding of coils in large production quantities.

Acme Electrical Insulations

Flexible Varnished Tubing in all standard sizes and colors.

Acme Radio Specialties

Audio Transformer windings.
Radio Frequency windings.
Magnet windings for Head Sets.
Enameled wire—especially the finest sizes, 40-44 B & S gauge.
Silk and cotton-covered magnet wire.
Enameled Aerial wire—single wire and stranded.



The rat-tat-tat of automatic hammers on the new skyscraper—the shrill whistle of the traffic policeman—the grating and grinding of street cars—the labored rumbling of heavily laden trucks—the harsh call of the newsboy breaking through the babel of voices—all the thousand and one street noises rise in a confused roar.

Power—

Klaxon's sound is not merely loud—it is penetrating! Its unmistakable 'saw-tooth' note is distinctly heard above the roar of downtown noises. No matter what other distracting sounds may fill the air—Klaxon's distinctive note is instantly heard and as quickly regarded.

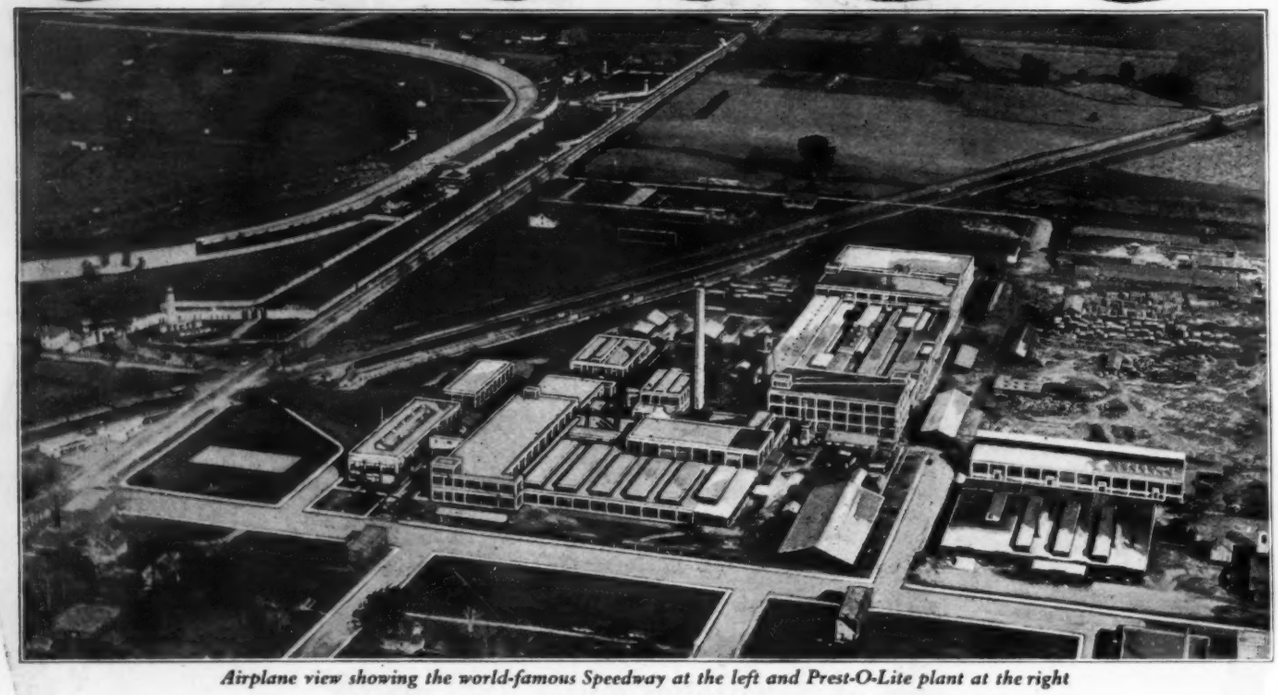
A Good Horn is Safety Insurance
Only Klaxon Quality is Good Enough

Genuine KLAXON Horns made only by

KLAXON

Company Newark, N. J.

Prest-



Airplane view showing the world-famous Speedway at the left and Prest-O-Lite plant at the right

The Speedway and Prest-O-Lite were built to better motoring

The same spirit which created Prest-O-Lite built the Speedway. The same organization made both—and each has been and is a direct contribution to the advancement of motoring. Because of the information gained in the great racing events on the Speedway, developments of tremendous importance in motors, tires, chassis construction and other features of the automobile have come about.

The huge Prest-O-Lite factory, just across the road from the Speedway, typifies the same devotion to advancement. Three times in eight years the plant has been greatly enlarged, to keep pace with the demands made upon it. Representing *"the oldest service to motorists,"* the plant itself symbolizes an organization that puts its full resources back of every Prest-O-Lite product and every Prest-O-Lite Service Station.

THE PREST-O-LITE COMPANY, Inc. *Indianapolis, Indiana*

New York Office: 30 East 42nd St. Pacific Coast Office: 599 Eighth St., San Francisco
In Canada: Prest-O-Lite Company of Canada, Ltd., Toronto

O-Lite

—the battery for cars

The Prest-O-Lite Battery lives up to the expectations aroused by the prominence of the plant. The constant care in selection of materials, rigid inspections and keen judgment of experts combine to present in Prest-O-Lite Batteries the power which distinguishes them, the reserve strength for emergencies and the long life and depend ability which make them excel for all-around, all-weather service.

—the gas for trucks

Prest-O-Lite Gas has always been the superior lighting equipment for trucks. With it, too, the service idea is fully carried out—as 22,000 Prest-O-Lite Gas Stations all over the country quickly exchange full tanks for empty ones, and you pay only for the gas. The equipment is approved by public authorities everywhere. It cannot be jarred, jolted or bumped out of commission, and it is as economical as it is completely satisfactory.

THE PREST-O-LITE COMPANY, Inc., *Indianapolis, Ind.*
Small Tank Sales Department

New York Office: 30 East 42nd St. Pacific Coast Office: 599 Eighth St., San Francisco
In Canada: Prest-O-Lite Company of Canada, Ltd., Toronto

THE GROWING IMPORTANCE OF *Lubrication* IN THE PUBLIC MIND

From practically every state we are getting constant reports of a rather startling increase of public interest in the question of lubrication.

The news of the remarkable savings made in repair costs by fleet owners through the methodical use of ALEMITE is spreading rapidly to the passenger car owner.

From a handy-man's job, lubrication has grown to be the biggest source of side-revenue for hundreds of garages and service stations. In one small town last year one dealer made $5,000 lubricating cars with ALEMITE. He has over 300 customers who have subscribed to a regular monthly lubricating service.

Car dealers, too, report this year, that in discussing upkeep costs an unusual proportion of purchases have hinged upon lubrication equipment—especially where the prospect is buying his second or third car.

THE BASSICK MANUFACTURING COMPANY
2654 N. Crawford Ave., Chicago, Ill.
Canadian Factory: Alemite Products Company of Canada, Ltd., Belleville, Ontario

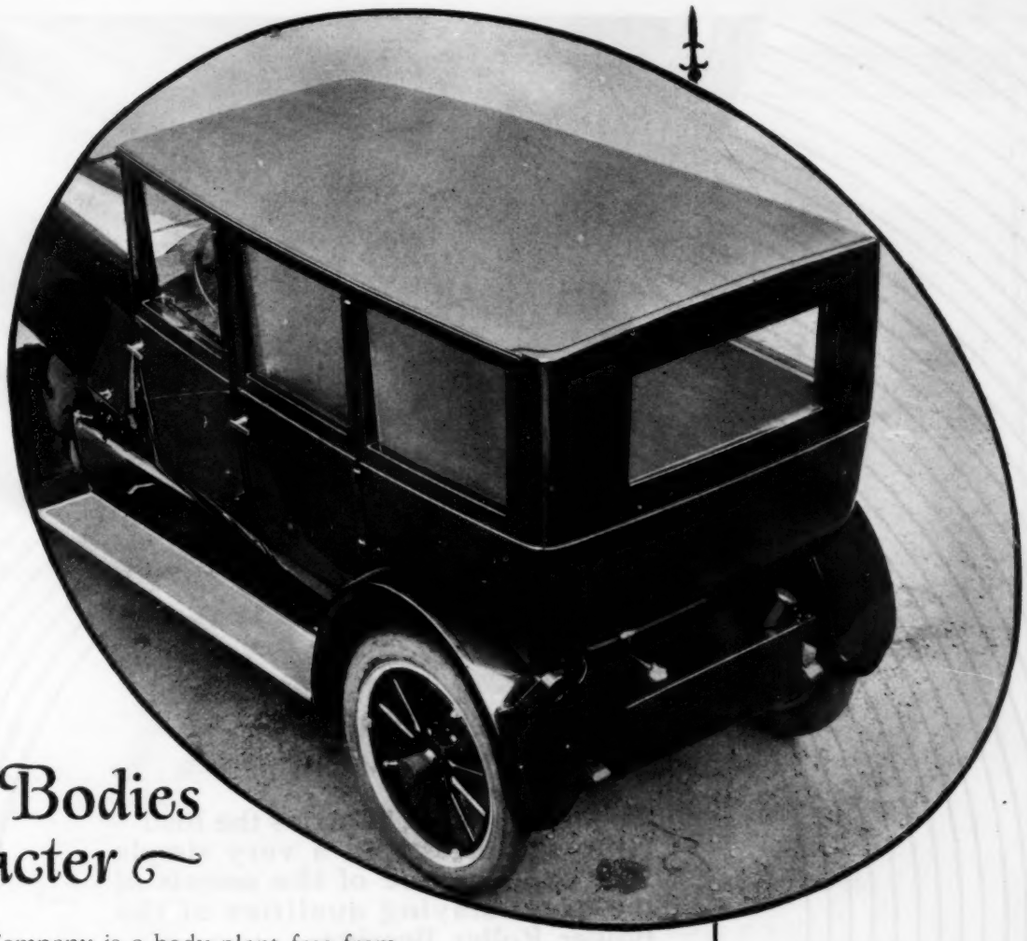
ALEMITE

High Pressure Lubricating System

Oil or Grease

The ALEMITE HIGH-PRESSURE LUBRICATING SYSTEM can be used with either oil or grease. But we recommend ALEMITE LUBRICANT, because it is a solidified oil which we have perfected especially for our System. It has all the benefits of oil, but at the same time is sufficiently solid to "stay put."

A Bassick Alemite Product



Raulang Bodies of Character

The Baker R & L Company is a body plant free from affiliations specializing in the making of closed bodies exclusively for the trade. This concentration of manufacture has resulted in a standard quality of workmanship at a medium price that was found heretofore only in higher priced bodies.

Our ample financing and stability insure our faithful performance of any contract; and our quantity production facilities, at least a thousand bodies per month, enable us to effect manufacturing economies that are reflected in our notably moderate prices. As a result, RAULANG Closed Bodies are found on many medium priced cars.

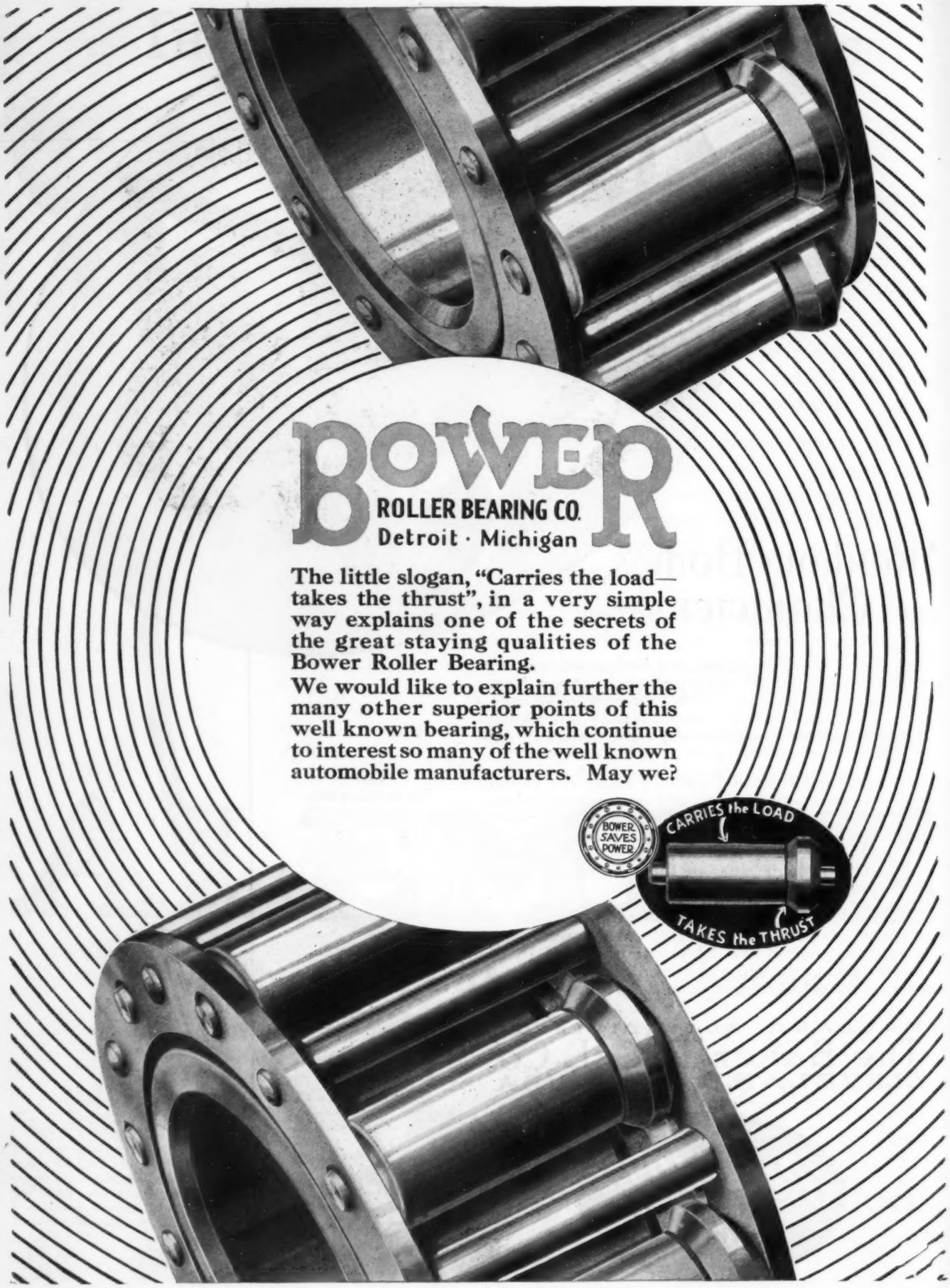
A RAULANG Body helps sell the car, because the salesman can point out those frequently unseen values of reserve strength and endurance that add to the comfort and to the silent operation of the car—not to mention the greater resale value.

Car Manufacturers

Let us do some "close figuring" on your closed body requirements.

RAULANG BODY DIVISION
The Baker R & L Co.
CLEVELAND, OHIO. U.S.A.

Raulang
TRADE MARK
AUTOMOBILE BODIES


BOWER
ROLLER BEARING CO.
Detroit · Michigan
The little slogan, "Carries the load—takes the thrust", in a very simple way explains one of the secrets of the great staying qualities of the Bower Roller Bearing.
We would like to explain further the many other superior points of this well known bearing, which continue to interest so many of the well known automobile manufacturers. May we?
BOWER SAVES POWER
CARRIES the LOAD
TAKES the THRUST

ULTIMATE STEELS

THE MEN RESPONSIBLE FOR THE ATLAS STEEL CORPORATION

IN the Personnel of the Board of Directors of the Atlas Steel Corporation, the buyer of fine steels finds ample assurance of the integrity and responsibility for which he rightfully looks.

Among the group of executives who direct the policy and operation of the Atlas Steel Corporation will be found men who, in individual capacities, are prominently identified with the advancement and development of the American steel industry. Associated with these executives as stockholders are a number of well-known engineers, financiers and men of affairs.

BOARD OF DIRECTORS

L. J. CAMPBELL, CHAIRMAN OF THE BOARD
Formerly President, The Electric Alloy Steel Co.

A. E. ADAMS
President, First National Bank, Youngstown, O.

T. J. BRAY
President, Republic Iron & Steel Co., Youngstown, O.

J. A. CAMPBELL
President, Youngstown Sheet & Tube Co., Youngstown, O.

J. F. CARTER
Vice-President, Manufacturers and Traders National Bank, Buffalo, N. Y.

D. W. COOKE
Associate Director, Cunard Steamship Co., Ltd., New York, N. Y.

E. B. GREENE
Vice-President, Cleveland Trust Company, Cleveland, O.

R. J. GROSS
President, Merchants National Bank, Dunkirk, N. Y.

MAURICE JOSEPH
Capitalist, Cincinnati, O.

SEVERN P. KER
President, Sharon Steel Hoop Co., Sharon, Pa.

L. A. MANCHESTER
General Counsel, Youngstown Sheet & Tube Company Youngstown, O.

S. LIVINGSTON MATHER
Secretary, Cleveland-Cliffs Iron Co., Cleveland, O.

W. D. MYRES
Secretary and Assistant Treasurer of the Corporation

H. E. NICHOLS
Treasurer and Assistant Secretary of the Corporation

R. L. O'BRIAN
O'Brian & Potter, Buffalo, N. Y.

C. S. THOMAS
Formerly President, DeForest Sheet & Tin Plate Co., Youngstown, O.

W. A. THOMAS
Formerly President, Brier Hill Steel Co., Youngstown, O.

H. F. VANDER VOORT
Wholesale Jeweler, Buffalo, N. Y.

JONATHAN WARNER
President, Trumbull Steel Co., Warren, O.

OFFICERS

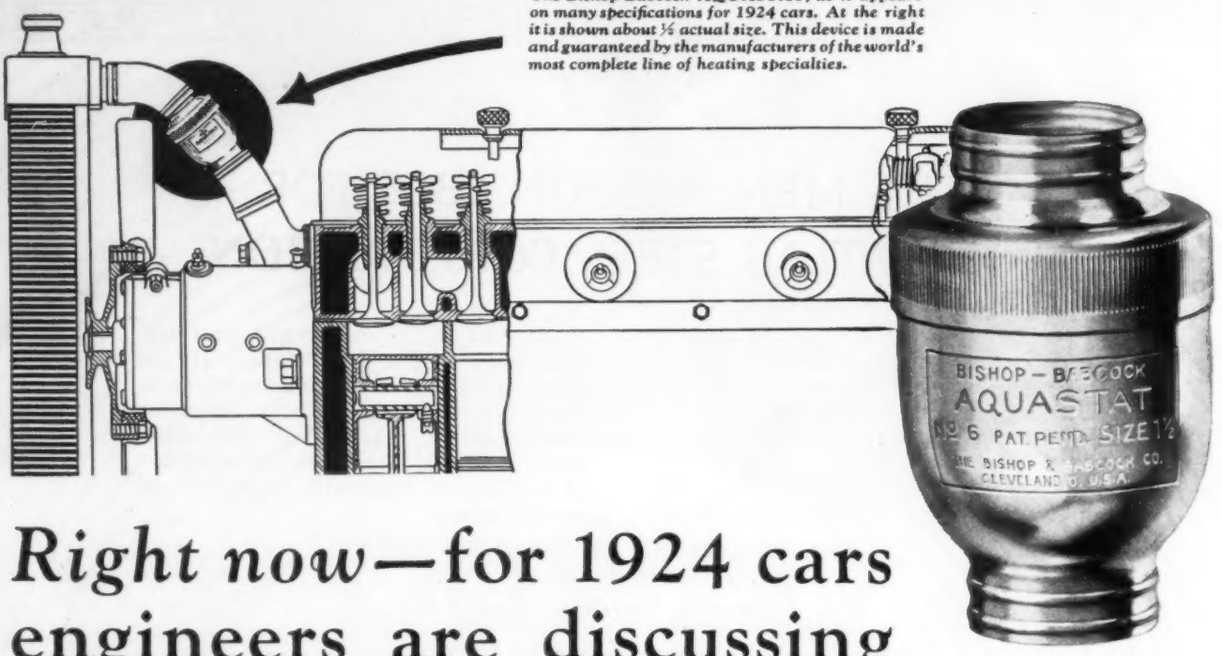
L. J. CAMPBELL, *President*
J. H. ROBERTS, *Vice-President*
W. D. MYRES, *Secretary and Assistant Treasurer*
H. E. NICHOLS, *Treasurer and Assistant Secretary*

Highest grades of fine steels, absolute uniformity, excellence of workmanship, fair prices, and delivery promises on which the buyer can rely, constitute the basis on which Atlas solicits a trial of its products.

High Speed Steels *Carbon Tool Steels* *Alloy Tool Steels*
Automotive Steels *Die Steels* *Special Analysis Steels*
Cold Drawn Products *Carbon and High Speed Drill Rod*

THE ATLAS STEEL CORPORATION

GENERAL OFFICES, DUNKIRK, N. Y.
Plants: DUNKIRK, N. Y. CHARLEROI, PA. WELLAND, ONT.
District Sales Offices: New York Boston Philadelphia Buffalo Pittsburgh Atlanta Indianapolis Cleveland Detroit Chicago St. Louis
Warehouses: Dunkirk, N. Y. Charleroi, Pa. Boston Detroit Chicago Welland, Ont.



The Bishop-Babcock **AQUASTAT**, *as it appears on many specifications for 1924 cars. At the right it is shown about ½ actual size. This device is made and guaranteed by the manufacturers of the world's most complete line of heating specialties.*

Right now—for 1924 cars engineers are discussing the Bishop-Babcock Aquastat

The engineers are now considering various possible improvements for the new models and they must exercise a high order of technical and business judgment.

Not only must they deal with engineering factors, but in addition they must keep in mind the broader phases of their work—public opinion, dealer opinion, competition, sales and service problems, etc.

On the one hand, the engineer adds no new equipment, however meritorious it may be, until the majority of car owners and buyers are definitely conscious of the unfilled need.

On the other hand, he cannot afford to lag behind competition, handicap his sales organization and weaken the position of his dealers. Thus, his general policy must be to keep in step with the trend of the industry, neither to lead the trend nor to follow it.

Now comes temperature control

Thirty-four manufacturers are today using as standard equipment some method of temperature control.

Contacts with engineers, factory officials, distributors, dealers and an unlimited number of owners point to this conclusion: that temperature control of the cooling water is generally recognized as a necessary part of good engine design by a majority of the men interviewed.

Engineers in more than 50 important organizations are now testing the Bishop-Babcock Aquastat. Several standard equipment contracts have already been placed. Tests are progressing rapidly and have been exceedingly favorable.

Bishop-Babcock Aquastat will be standard equipment on the 1924 models of many prominent manufacturers.

What the AQUASTAT will do

The Bishop-Babcock Aquastat is guaranteed to give the following results:

(1) Adjust water temperature to seasonal conditions and prevent over-cooling.
(2) Maintain constant temperature of water around combustion chamber and cylinders.
(3) Warm up engine quickly and reduce use of choke.
(4) Save fuel and reduce carbon deposits.
(5) Minimize dilution of oil in crank case.

To check the danger of freezing, 10% seepage is allowed.

And by reason of its design, the Aquastat cannot handicap the flow of water in hot weather.

* * *

A special type of the Bishop-Babcock Aquastat for thermo-syphon cooling systems is now available. It is submitted for tests to the engineers and to the trade as the final product of exhaustive experimental work.

* * *

We invite tests from all manufacturers of automobiles and trucks, distributors and dealers, on both types of Aquastat.

THE BISHOP & BABCOCK COMPANY
Automotive Specialties Division
CLEVELAND, OHIO

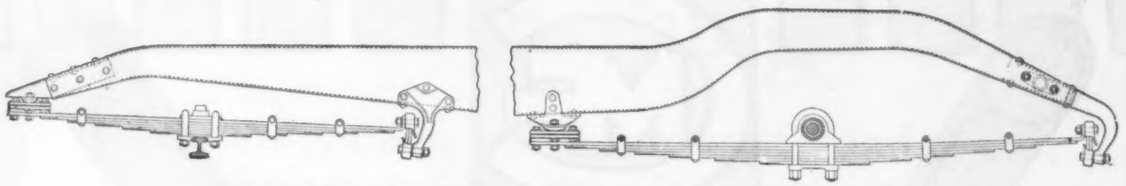
Bishop-Babcock

AQUASTAT

Retail Price $10.00

Two hose sizes 1¼" and 1½"

BELFLEX
FABRIC SPRING SHACKLES

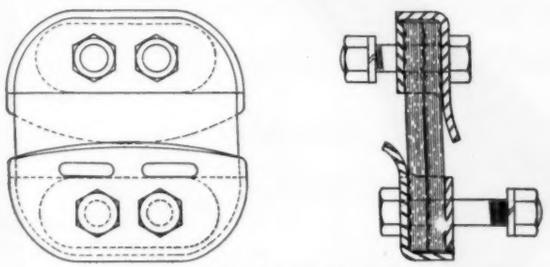


Belflex Fabric Spring Shackles applied to car with semi-elliptic springs.

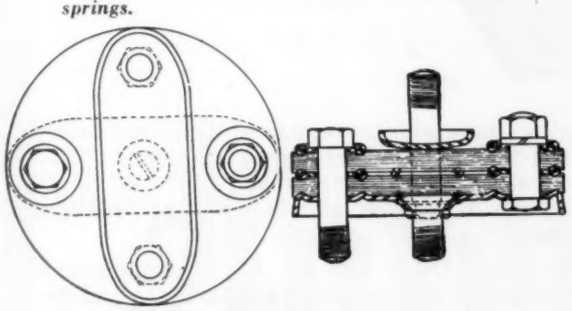
The Belflex Fabric Spring Shackle is fast becoming one of the most important completed chassis engineering developments in recent years. It is possible to use Belflex equipment on all types of spring suspension.

This fabric spring shackle achieves, without increased cost to the manufacturer, the following important advantages:

Elimination of from 12 to 16 lubricating points from the average chassis.



The Tension Shackle can be supplied in various sizes to fit any weight of car. It is the result of over three years of development work, and there is a valid reason for every detail. It is used at the rear ends of the springs.



The Pivot Shackle used at the front ends of the springs. In addition to its other advantages it takes the twisting action produced by uneven deflections away from the main leaf of the spring, giving the spring greater flexibility and increasing its life.

Substitution of noiseless fabric insulation for metallic contact between the sprung and unsprung parts of the car.

Freer action—improved riding qualities and greater life to springs.

Belflex Fabric Spring Shackles keep the car quiet without attention.

These and other important advantages of the Belflex Spring Shackle are the result of over three years of development work.

Another consideration for manufacturers and automotive engineers is the elimination of spring eyes and eye forming operations, which greatly simplifies the springs, and reduces their cost considerably.

Let us show you how Belflex equipment supersedes the old spring shackles with their squeaking and rattling bolts and bushings.

Belflex Engineers are ready to aid you in the design of equipment to conform to your chassis requirements.

Write for information today.

The BELFLEX Corp.

AUTOMOTIVE PRODUCTS

366 Madison Ave., New York City

Patents on Belflex Fabric Spring Shackles have been granted, and others are pending, in the U. S. and other countries

CHAMPION

The man who shops around, buying drop forgings here and there, has all the hard boiled evidence any man can desire to convince himself that all forgings are not alike and that a forging is something more than just a piece of steel formed by so many hammer blows. And that evidence is in his own office. A comparison of cost sheets showing finishing time will tell facts that no salesman dares state.

If by any chance he has bought Champion Forgings there will be unquestionable evidence that they effect true economies thru accuracy to blue print specifications, alignment and uniformity of metal. Of tool adjustments, there will be fewer; of defects causing tool breakage, there will be none. Try it out on your own cost sheets. Then send us your blue prints and specifications.

THE CHAMPION MACHINE & FORGING CO.

3695 East 78th Street **Cleveland, Ohio**

NEW YORK OFFICE—30 Church St. PHILADELPHIA OFFICE—Bourse Bldg.

DETROIT OFFICE—705 Ford Bldg.

DROP FORGINGS

That Something Else

After the manufacture itself—and before as well—there is the service-factor that completes your transactions to your pleasure or to your extreme dissatisfaction.

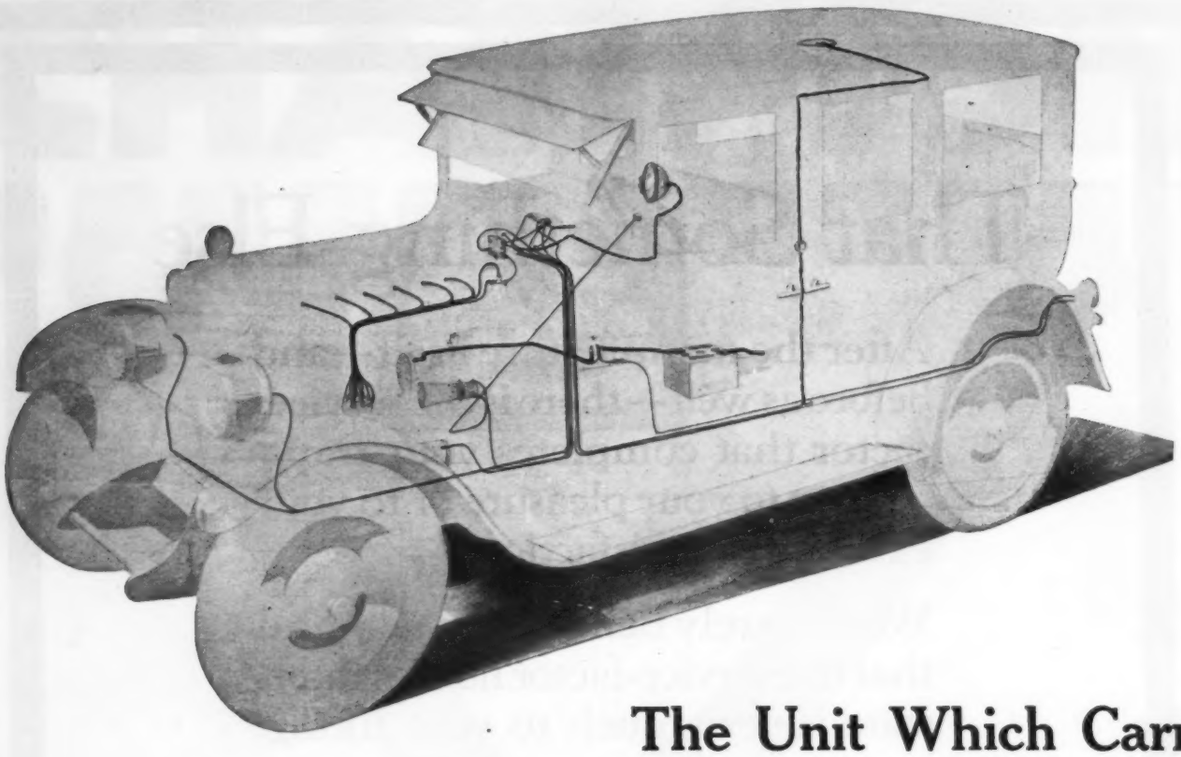
We sincerely believe you will find that the service-factor here at Interstate is very much to your liking.

We are trying consistently to make it that way—every man of us.

Open Hearth Alloy Steel Ingots, Billets, Bars
Wire Rods, Wire Nails, Rivets and Cut Tacks
Iron Bars and Railroad Tie Plates

INTERSTATE IRON & STEEL CO.
104 South Michigan Avenue
CHICAGO

Interstate Steels



The Unit Which Carries Life to the Vital Parts of Your Car

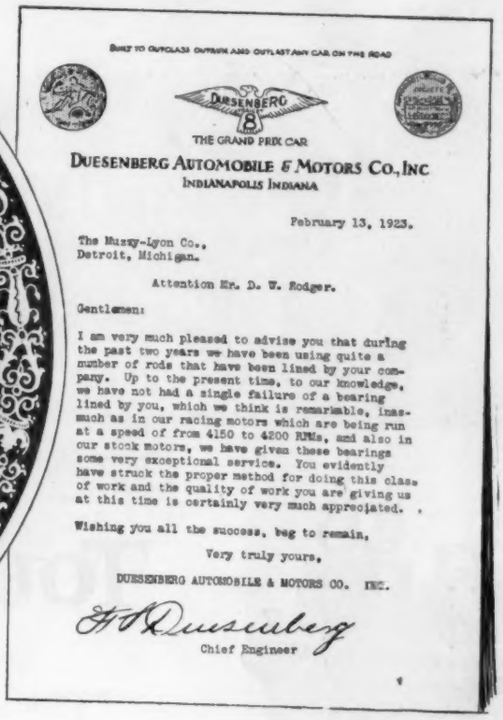
A loosened contact—a piece of insulation on the starting or ignition cable oil soaked or cracked, and the irritated motorist loses sight of the mechanical perfection of your car.

It is not for him to understand why the car won't run. His thoughts are—that long walk to the nearest telephone—that broken business engagement—and that annoying expense of receiving help from the service station.

The quality of Packard Cable is in keeping with the other vital units you have so skillfully perfected. As a unit of good repute, it affords engineering satisfaction and important sales arguments.

The Packard Electric Company

WARREN, OHIO



BUILT TO OUTCLASS OUTRUN AND OUTLAST ANY CAR ON THE ROAD

DUESENBERG

THE GRAND PRIX CAR

DUESENBERG AUTOMOBILE & MOTORS CO., INC.
INDIANAPOLIS INDIANA

February 13, 1923.

The Muzzy-Lyon Co.,
Detroit, Michigan.

Attention Mr. D. W. Rodger.

Gentlemen:

I am very much pleased to advise you that during the past two years we have been using quite a number of rods that have been lined by your company. Up to the present time, to our knowledge, we have not had a single failure of a bearing lined by you, which we think is remarkable, inasmuch as in our racing motors which are being run at a speed of from 4150 to 4200 R.P.M., and also in our stock motors, we have given these bearings some very exceptional service. You evidently have struck the proper method for doing this class of work and the quality of work you are giving us at this time is certainly very much appreciated.

Wishing you all the success, beg to remain,

Very truly yours,

DUESENBERG AUTOMOBILE & MOTORS CO. INC.

F. S. Duesenberg
Chief Engineer

Duesenberg is a name for years intimately connected with the most searching tests of parts and materials—motor car racing.

Duesenberg has used *"Mogul Alloy Genuine"* special connecting rod metal in his motors for several years, and it has never failed him, under any condition, regardless of how severe it may have been.

No better evidence of quality could be asked for than Mr. Duesenberg's letter reproduced above.

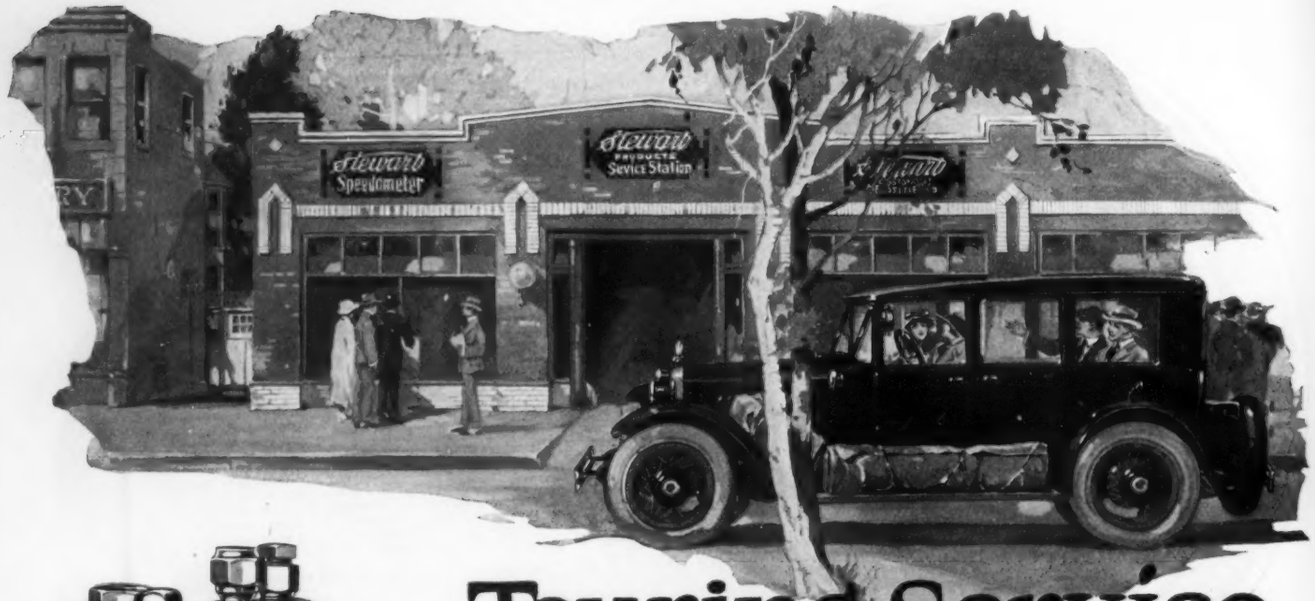
Mogul metal fulfills every requirement of the ideal metal—pouring easily without trouble from shrinkage or blow holes, producing a bearing of very fine grain, of exceptional wearing qualities, and yielding more bearings per pound than the average bearing alloy.

MUZZY-LYON COMPANY, DETROIT, MICH.

Write for a copy of "Mogul Alloys for Better Bearings" or better still, order a trial box today.

Mogul

Engine Bearings *and* Bearing Alloys



Touring Service

THE purchaser of a car buys transportation. But transportation is of little value unless backed up by expert service. When touring from one state to another, the car owner has a right to expect that he can obtain expert service at a point not far distant, no matter where he may be. In fact, prospective purchasers are now seriously considering the service obtainable, before they buy.

What a burden the car manufacturer must bear who is obliged to establish nation-wide service, not only for the motor and chassis, but for necessary equipment as well.

What a relief it is to the manufacturer who has Stewart-equipped his car to know that service on all Stewart equipment has been provided for in a more than satisfactory manner.

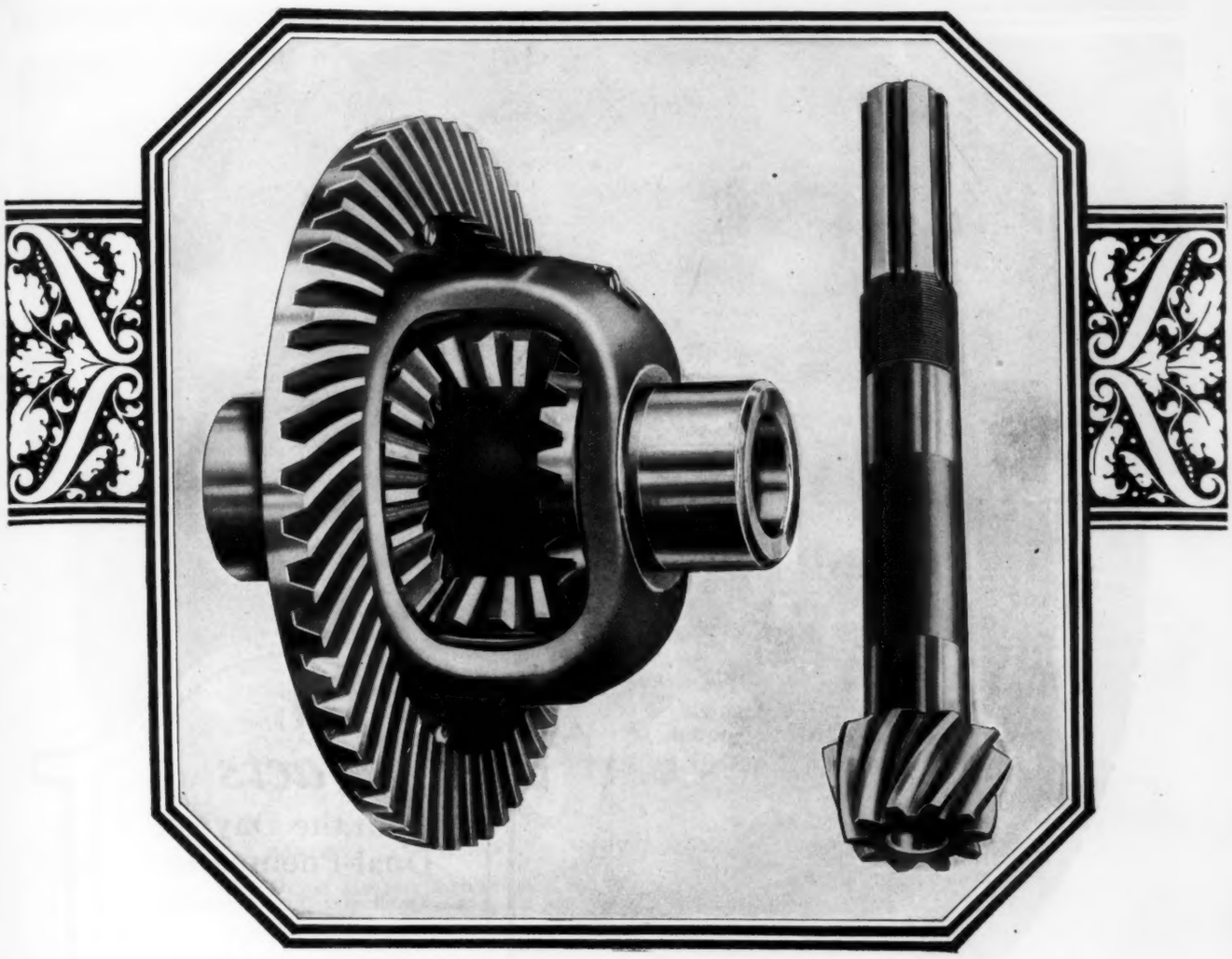
Long ago we solved this service problem with the establishment of a chain of Service Stations throughout the world, manned by experts who service Stewart equipment exclusively; fifty-four stations in the United States alone, accessibly located in the nation's largest cities.

And the remarkable fact is that although this Stewart Service system has no equal, the Stewart equipment on a car is known to require less service than any other standard equipment.

Stewart-Warner Speedometer Corporation
CHICAGO, U. S. A.

Stewart
Vacuum Tank and Speedometer

Stewart
CUSTOMBILT ACCESSORIES
USED ON 8 MILLION CARS



THE confidence which so many motor car manufacturers place in the Brown-Lipe-Chapin products is due to their record of unfailing superiority since the beginning of the industry.

Manufactured at Syracuse, N. Y.

BROWN-LIPE-CHAPIN

DIFFERENTIALS — BEVEL DRIVE GEARS

6 *Facts*

about the Dayton Dual-Pneumatic

1—Small size tires, economical and easy to handle.

2—Only one size of tire, interchangeable all around.

3—All rim clamps easily accessible, tires can be changed quickly.

4—Spoke wheel with two felloes, no pockets in which stones or dirt can lodge.

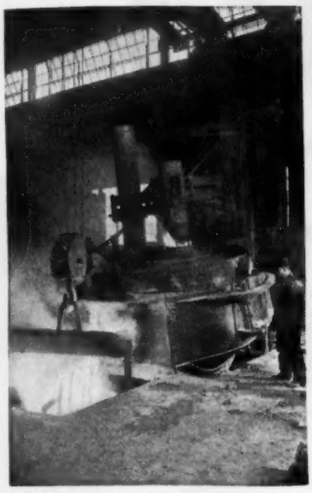
5—Decreased chassis height, making it easier for passengers to enter and leave.

6—Dayton's unique construction, hollow spokes and rims cast in one piece of electric furnace steel; greatest strength with least weight.

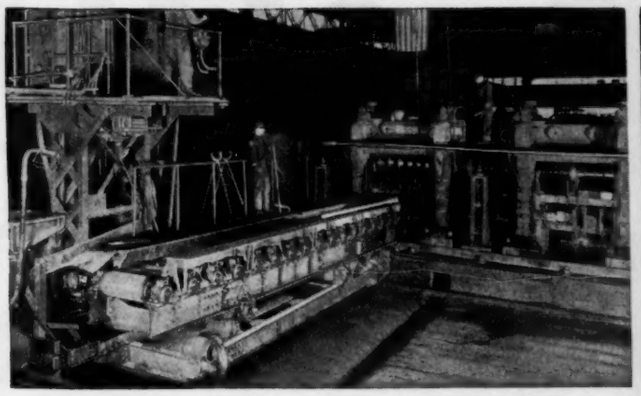
It will pay you to investigate.
Write us for further information.

The Dayton Steel Foundry Co.
Dayton, Ohio

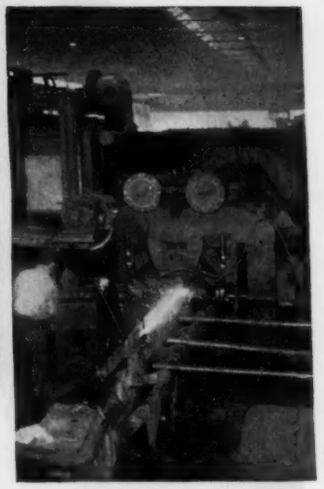
Dayton
Steel Truck Wheels
PATENTED



One of the Electric Furnaces



Part of the Timken Rolling Mill



In the Timken Tube Mill

100,000-Mile Timken TAPERED ROLLER BEARING Steel

The durability of Timken Tapered Roller Bearings is not wholly due to the fact that the steel is clean, thoroughly deoxidized, electric steel, made in the electric steel mill owned and operated by The Timken Roller Bearing Company.

Nor is Timken durability due wholly to the fact that the steel is high chromium steel which gives the rollers of anti-friction bearings the greatest possible resistance to wear and fatigue and shock.

Nor is Timken durability due wholly to the fact that in the Timken steel mill, oxidizing and reducing operations are controlled at all times during the making of the heat—a condition on which depends the successful, subsequent case-carburizing and pack-hardening of the parts of Timken Bearings—which gives them their glass-hard outer surfaces, with tough, elastic, inner cores.

Timken durability is due to the successful co-ordination of all these factors; the exacting specifications to which the special Timken electric steel is made; *and* to the high chromium content of the steel; *and* to the case-carburizing and pack-hardening of the finished parts; *and* to the accuracy of fabrication; *and* finally, to the very design of the bearing, which permits easy, quick, adjustment for the inevitable wear that *must* eventually follow motion.

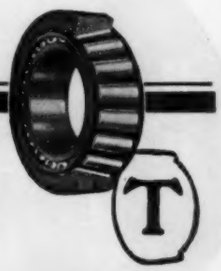
The Timken Roller Bearing Company is the only bearing company which makes its own steel and its own seamless tubes, and rods, in its own electric steel mill, rolling mill, tube and rod mill.

The Analysis of Timken Steel is:

Carbon	.15— .29
Manganese	.45— .60
Phosphorus	.04
Sulphur	.04
Silicon	.15— .20
Chromium (Cups & Cones)	.40— .50
Chromium (Rollers)	1.00—1.20

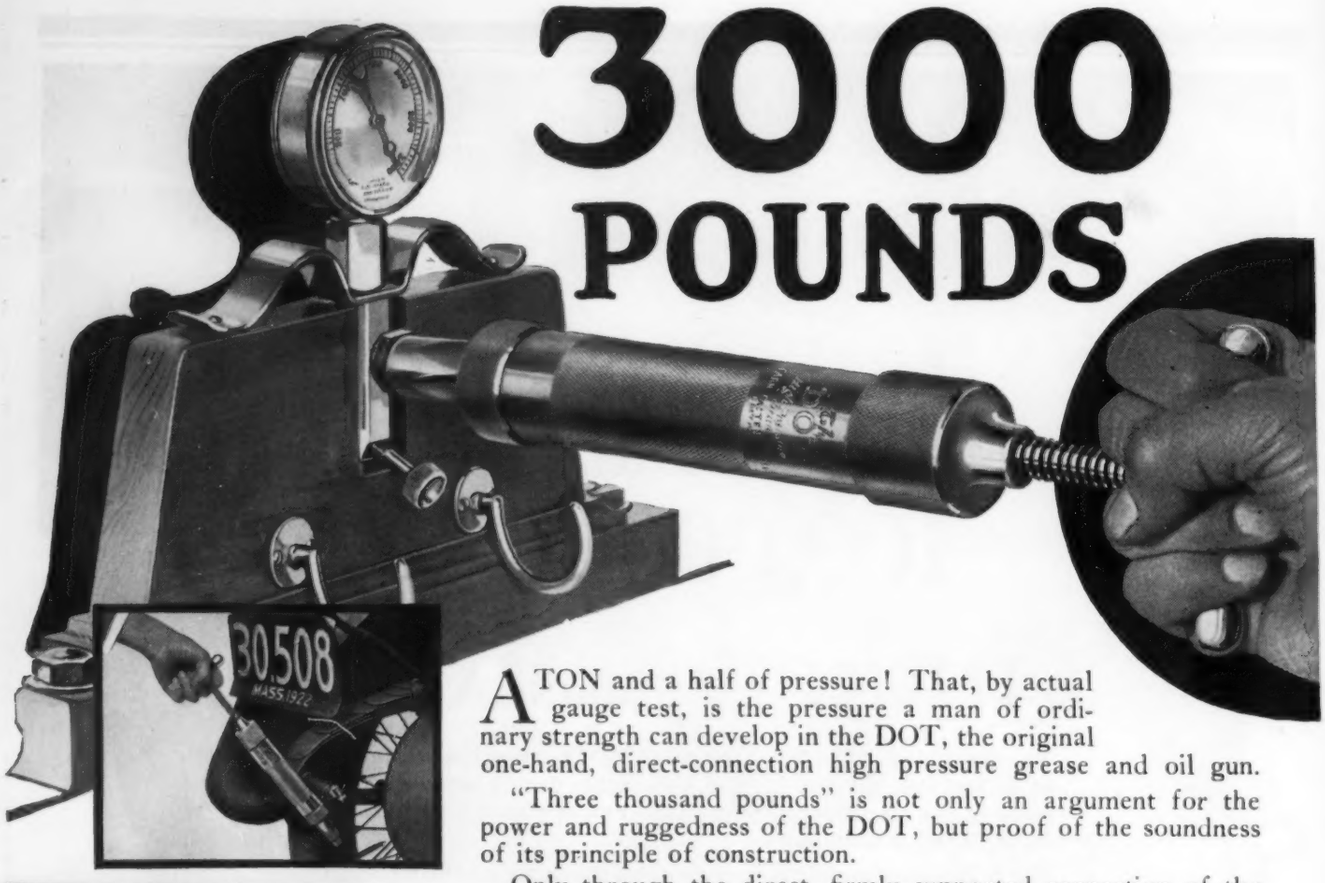
The Timken Roller Bearing Co
CANTON, OHIO

© 1923, By The T R B Co, Canton, O



TIMKEN
Tapered
ROLLER BEARINGS

3000 POUNDS



A TON and a half of pressure! That, by actual gauge test, is the pressure a man of ordinary strength can develop in the DOT, the original one-hand, direct-connection high pressure grease and oil gun.

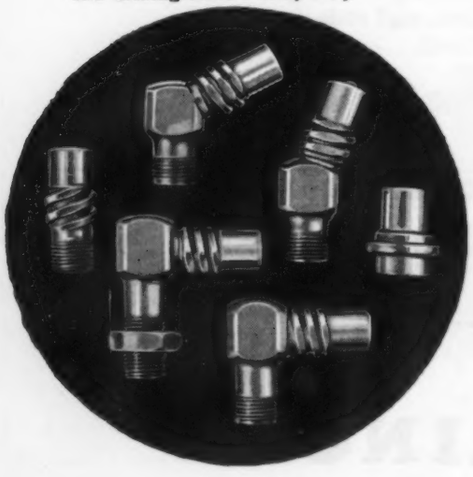
"Three thousand pounds" is not only an argument for the power and ruggedness of the DOT, but proof of the soundness of its principle of construction.

Only through the direct, firmly supported connection of the DOT can such pressure be applied without leakage. The burly, case-hardened steel nozzle of the DOT locks *solidly* to the DOT machine-faced steel nipple. No weak connecting member—nothing to give way!

And the DOT is as handy as it is sturdy. ONE HAND is all you need for every step of the lubricating operation; one hand to connect and lock gun to nipple, one hand to develop pressure and inject lubricant, one hand to unlock and disconnect gun. No awkwardness; no messiness; no slippery coupling; no finger bruising; no pliers! Unfailing automatic valve enables use of oil as well as grease, and permits pressure to remain in the gun.

FIFTY-EIGHT car and truck manufacturers have in two short years adopted the DOT as standard equipment. ONE HUNDRED leading jobbers and TWO THOUSAND dealers sell it. Send for descriptive folder.

Easy access to any lubrication point on any chassis! NIPPLES for the DOT system are made in all the various forms and angles necessary for direct, one-hand connection. Nipples are steel, have ball check valve and will not leak. Slotless snap-on dust cap is of attractive design and covers valve and locking-thread completely.



CARR FASTENER COMPANY, Boston 39, Mass.

Makers of the "DOT" line of fasteners

Branch Offices—40 Selden Ave., Detroit
47 W. 34th St., New York

CARR FASTENER CO. OF CANADA, LIMITED
HAMILTON, ONTARIO

The **DOT** TRADE MARK

high pressure **LUBRICATOR**

"WHITNEY"

LONG SERVICE

ROLLER CHAINS

For Motor Trucks, Tractors and Machinery

THE MOST DURABLE, Therefore
THE MOST ECONOMICAL

Cotter Detachable Type

Now that the motor truck is handling so much of the freight that was formerly cared for by the railroads, it must run on a schedule almost as exacting as that of the railroad train itself. This emphasizes the necessity of selecting a chain which can be relied on under all conditions of speed, road, and weather.

AVOID TROUBLE BY
SPECIFYING "WHITNEY"

THE WHITNEY MFG. CO., Hartford, Conn.

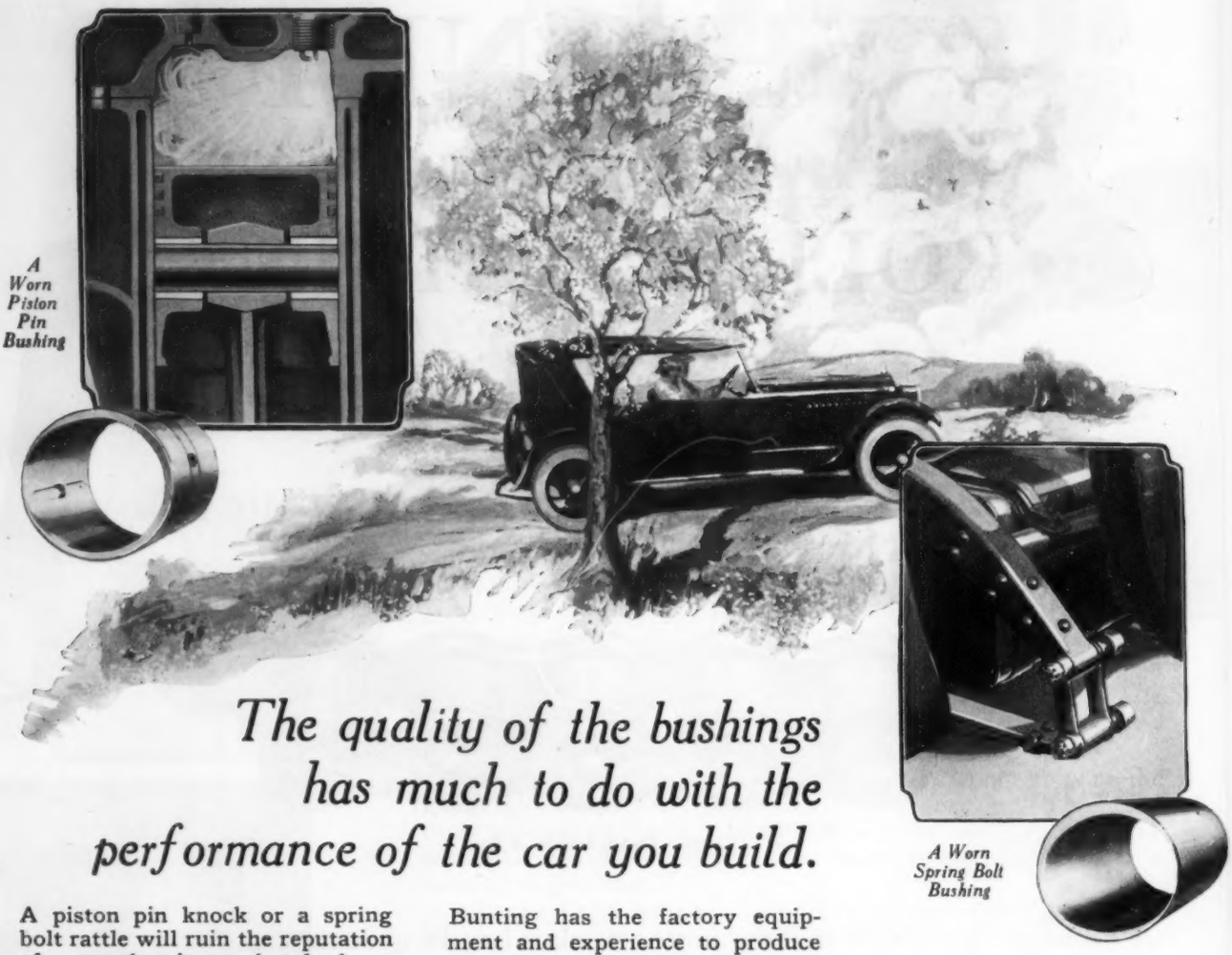
CHAINS **KEYS AND CUTTERS** **HAND MILLING MACHINES**

NEW YORK
L. C. Biglow & Co., Inc.
243 W. 55th St.

BOSTON
George C. Stell
200 Devonshire St.

PHILADELPHIA
R. J. Howison
624 Race St.

SAN FRANCISCO
A. H. Coates Co.
770 Mission St.



A Worn Piston Pin Bushing

A Worn Spring Bolt Bushing

The quality of the bushings has much to do with the performance of the car you build.

A piston pin knock or a spring bolt rattle will ruin the reputation of a car that is one hundred per cent good in other and perhaps more important details. The bronze bushings in any car represent an infinitesimal fraction of its cost, but a big percentage of its performance value.

Bunting Bushings in Automotive mechanisms are accepted by trade and public as an evidence of the car builder's determination to employ only the best in the making of his product.

Bunting has the factory equipment and experience to produce any bronze bushing bearing your need may demand.

Most of your requirements can be supplied from Bunting's list of "Ready Made" bronze bushings. This list includes 268 different sizes of completely finished bronze bushings ready for assembly. "They're always in Stock" ready to ship. Long run prices even on small lots. Write for Stock list L.

For your special order lines Bunting has pattern and tool equipment for over 10,000 different designs and practically unlimited foundry and machine shop capacity.

THE BUNTING BRASS & BRONZE COMPANY

TOLEDO, OHIO

New York
245 *West 54th St.*
Circle 0844

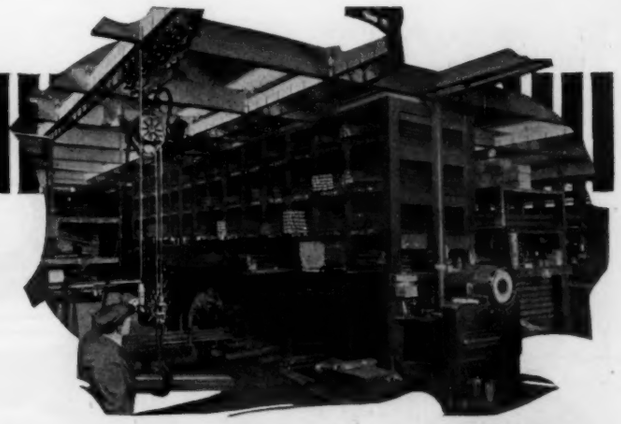
Chicago
722 *S. Michigan Ave.*
Wabash 9153

Cleveland
710 *St. Clair St., N. E.*
Main 5991

Boston
36 *Oliver St.*
Main 8488

San Francisco
198 *Second Street*
Douglas 6245

BUNTING BUSHING BEARINGS
PATENTED



Factors in Strom BALL BEARINGS Supremacy

No. 2—The Raw Stock Room

Here is the impregnable foundation of the perfect performance of STROM ball bearings. STROM bearing steel—made to our own specifications, by America's most expert steel workers, yet subjected to searching chemical and physical tests before use—has that unvarying and exact texture which alone could withstand the untiring watchfulness and machine precision of STROM ball bearing production. Such raw material—plus constructive testing and analyzing continued from bar-stock to shipping-box—is an important factor in determining STROM supremacy.

STROM guaranteed ball bearings, on *new* or *replacement* work, reduce friction to the vanishing point—

"Wherever a Shaft Turns"

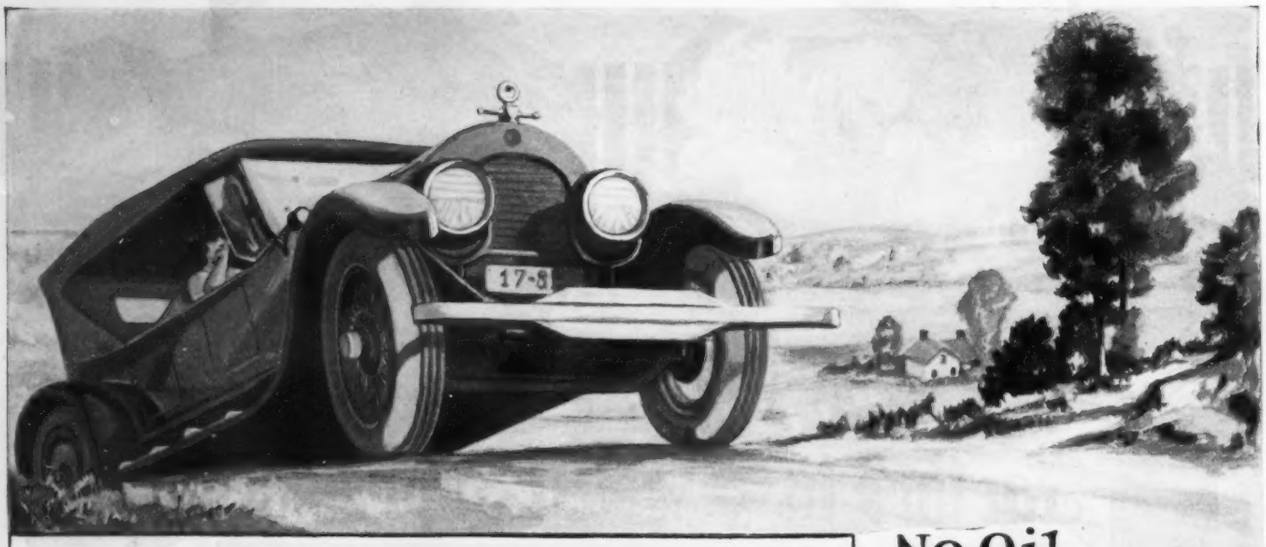
(1976)

Strom BALL BEARINGS

U. S. Ball Bearing Mfg. Co.
(Conrad Patent Licensee)
4533 Palmer St., Chicago, Ill.

An Organization Built for Precision

Scientific in Principle and Practice



A new and better principle in Vacuum Fuel Feed-

Oil-Vac, the Kingston Vacuum Fuel Feeding System, does away entirely with the intake manifold as a suction source, utilizing instead the suction produced by the proper proportioning of the oil circulating pump.

With *Oil-Vac* there is certainty of increased suction with increased engine speed. When the greatest amount of fuel is needed, as in the case of long grades or at high speeds, the greatest amount is actually being delivered to the motor.

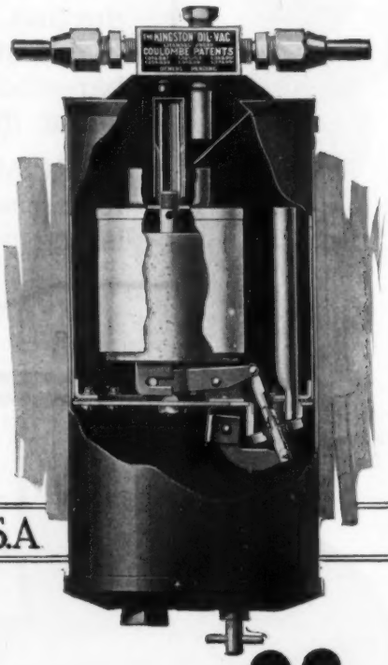
With *Oil-Vac* disturbance of carburetion is at a minimum, and crank case dilution is lessened to a marked degree. Oil runs cooler and lubrication is more efficient.

Automotive engineers generally are taking a deep interest in this *new* principle in vacuum fuel feed. A number of leading manufacturers have already adopted *Oil-Vac* as standard equipment, and many others are investigating its merits. A line to the manufacturers will bring complete information.

No Oil
No Vac
No Gas

With *Oil-Vac* the vacuum ceases when the oil supply becomes exhausted. No motor should run without oil, and no motor can run without oil for long without serious damage. This is one added feature of importance with *Oil-Vac*, a factor of safety that is worthy of consideration.

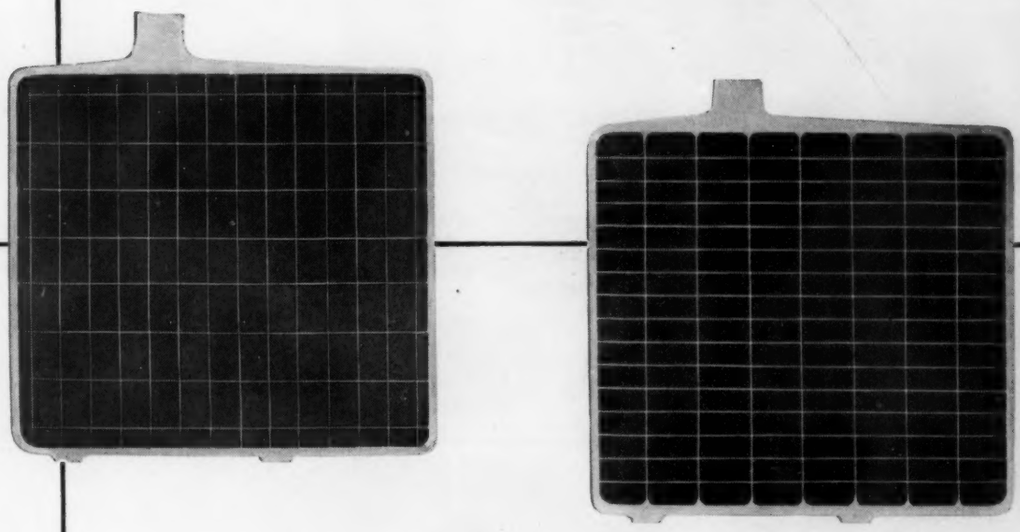
Send for the *Oil-Vac* Booklet



BYRNE, KINGSTON & CO. KOKOMO, INDIANA, U.S.A.

Branches
New York, 245 W. 55th St. Chicago, 1430 Michigan Ave.
Dallas, 2218 S. Harwood St. Detroit, 4610 Woodward Ave.
Boston, 15 Jersey St. Los Angeles, 1417 W. Pico St.

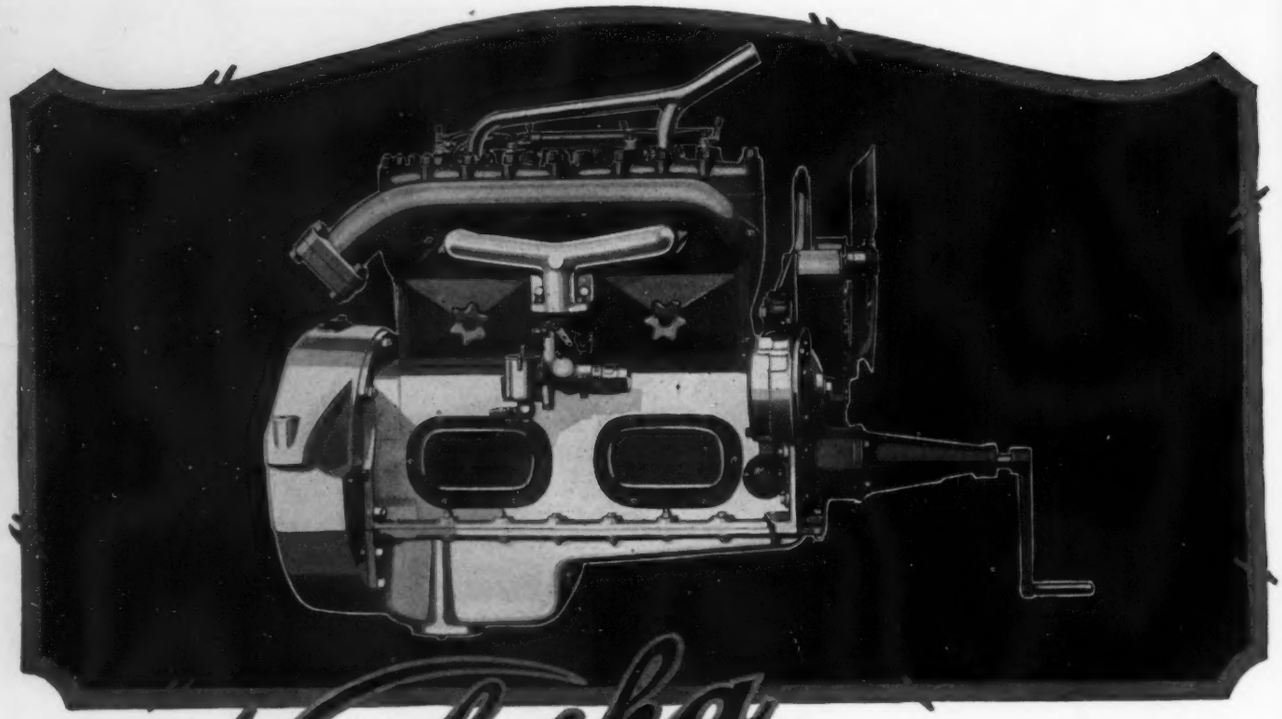
"Oil-Vac"



THE plates in the Westinghouse Battery are a compromise between the so-called thin and thick plates. The weakness of the thin plate (buckling) has been practically overcome. So has the objection to the thick plate, viz., failure of the acid to penetrate to inside active material on high discharges.

WESTINGHOUSE UNION BATTERY CO.
Swissvale, Pa.

WESTINGHOUSE
BATTERIES



Waukesha
TRADE MARK

BUS and TRUCK MOTORS

Even though there exists so many exclusive and distinguishing features in the design, construction and workmanship of the Waukesha Bus and Truck Motor, business men generally, like those in the industry, prefer to acclaim its great economy, and why not?

It has made possible better transportation and hauling at a radically reduced cost. Its existence represents more trips made, more tons moved, more years of compensating working life at decidedly less expense.

Its remarkable performance records are not only worthy of but command the fullest consideration of everyone with whom transportation is a daily problem.

We shall be pleased to forward complete and detailed information to all those making a request.

The WAUKESHA MOTOR COMPANY, Waukesha, Wisconsin

Cost of Reputation

The amount of money spent by this company in advertising, has invariably been overestimated by those unacquainted with the figures.

There are good reasons for this in the fact that Timken publicity has been consistent and long-continued; and still more in the fact that Timken Axles have verified the conservative statements of Timken.

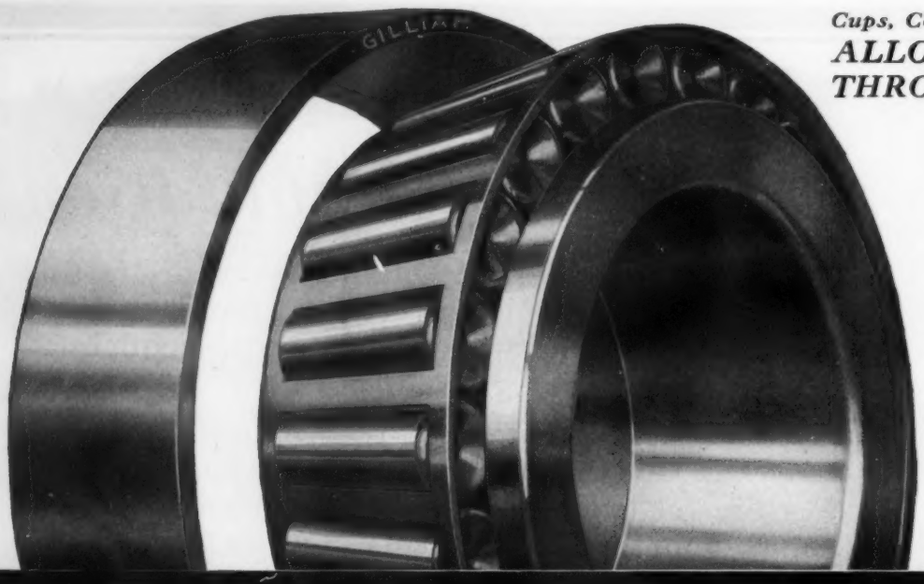
It is not by brilliant advances and sharp retreats but by the steady progress of twenty years—a new idea here, a little added quality there, a constant forward development of axle design—that the name Timken has identified itself with dependability.

Thus factory vigilance and advertising truthfulness have together worked a reduction in selling cost both for us and for Timken-equipped cars.

The use of Timken Axles by car builders who had for years built their own axles proves not only Timken reputation but also the reasonable cost of that reputation.

THE TIMKEN-DETROIT AXLE COMPANY, DETROIT, MICH.
Sole Representatives in the British Isles:
AUTOMOTIVE PRODUCTS COMPANY, 3, Berners Street, London, W. 1.

Magazine advertising is economical and productive in proportion as it is supported by the word-of-mouth advertising of the buyers.



Cups, Cones, Rollers
ALLOY Steel
THROUGHOUT

The Rollers in GILLIAM Tapered Roller Bearings form true rolling cone lines when in operation, and they do not depend upon the cage to keep them in axial alignment. This is accomplished by the patented feature on the thrust rib of the cone.

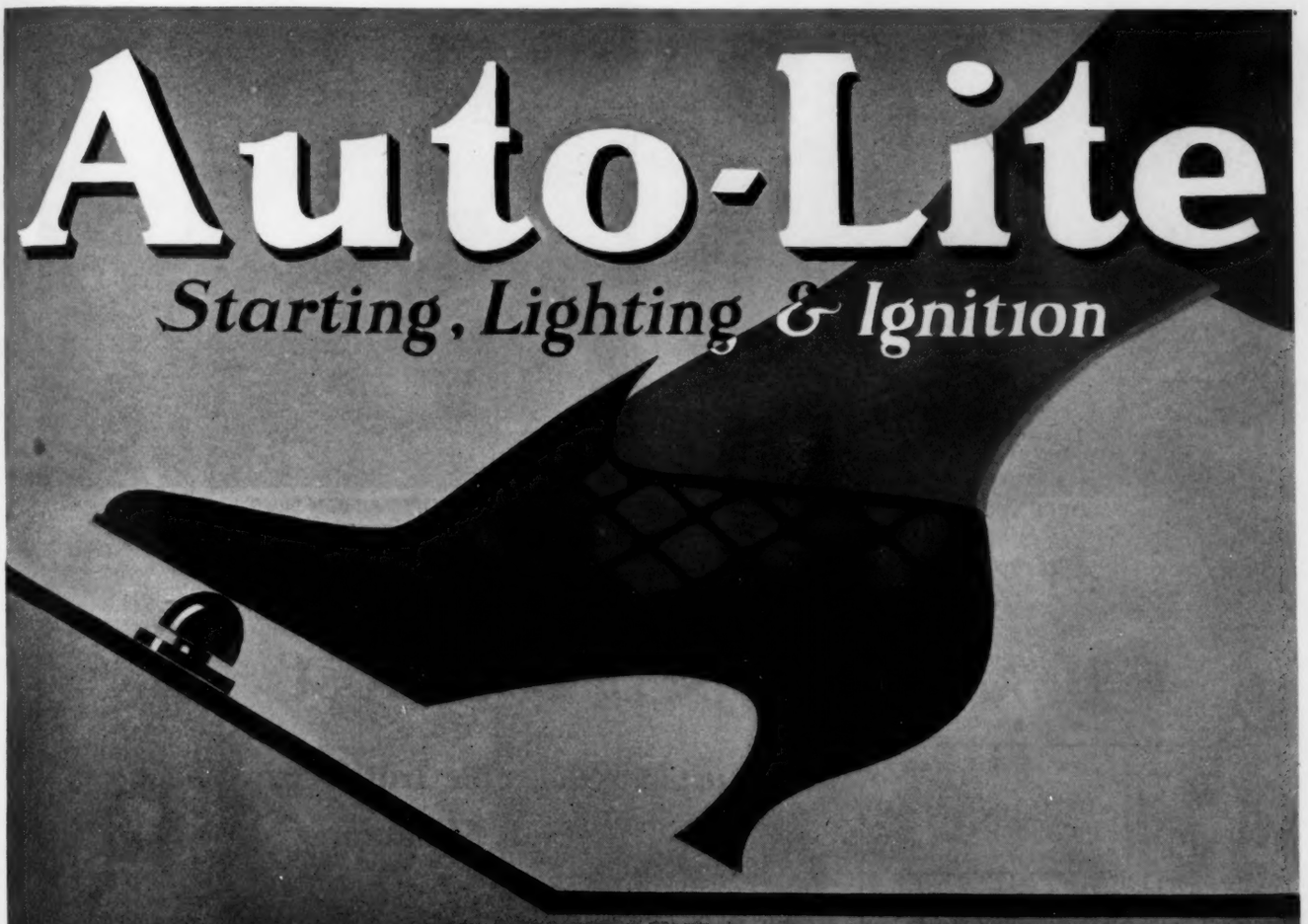
Axle manufacturers using Gilliam Tapered Roller Bearings include: Adams, Clark, Columbia, Flint, Salisbury, Sheldon, Standard Equipment, Torbensen, U.S., Vulcan, Wisconsin.

GILLIAM TAPERED ROLLER Bearings

The Gilliam Mfg. Co. - - Canton, Ohio

Auto-Lite

Starting, Lighting & Ignition



THE superior excellence of the Auto-Lite System is conclusively shown by the fact that between 40 and 50 per cent of all electrically equipped motor vehicles (excluding Fords) are equipped with Auto-Lite.

Public confidence in the ability and reliability of the Auto-Lite system results from the years of satisfactory experience of millions of car owners all over the world.

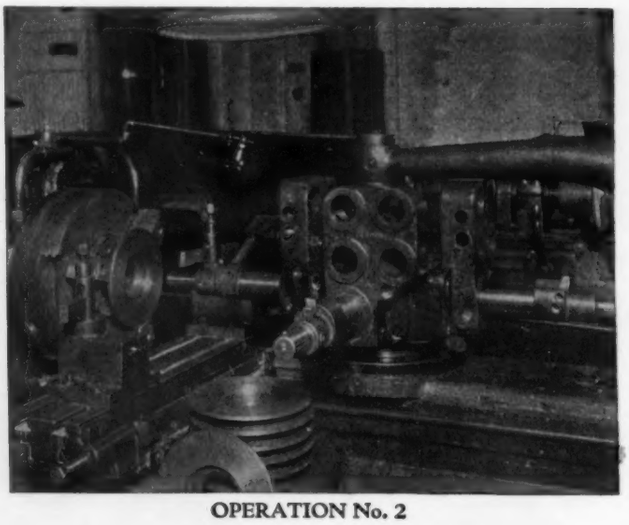
Could Auto-Lite be the largest builder of electrical systems unless the car owners received maximum service and long life with minimum service attention?

THE ELECTRIC AUTO-LITE COMPANY

Offices and Works: TOLEDO, OHIO

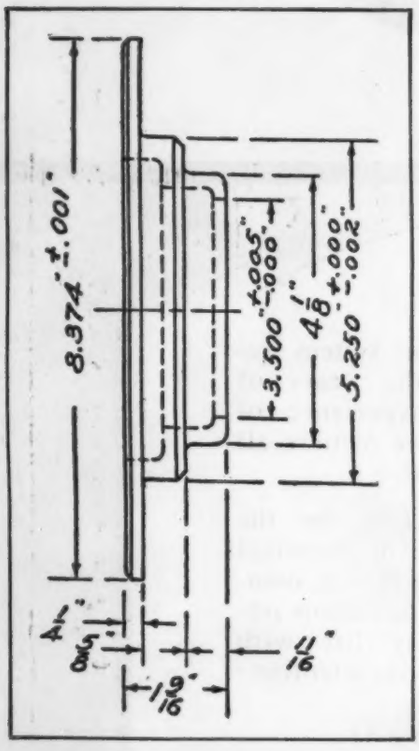
Detroit Sales Office: 1309 KRESGE BLDG.

OPERATION No. 1



OPERATION No. 2

41% Increased production—
10% Decreased tool cost



Turning Malleable Iron Wire Wheel Hub Mountings

First cost of Stellite Tools for this Job	$35.46
Scrap Value on Returned Stellite Ends	5.95
Net Cost of Stellite Tools for Set-Up	$29.51
First Cost of Tools of Other Cutting Metals	10.05
Difference in First Cost	$19.46

But—

One Set of Stellite Tools Turned	5,750 Pieces
One Set of the Other Tools Turned	1,754 Pieces
Number of Sets of Other Tools Saved by Investing in One Set of Stellite Tools	2¼ Sets

And—

1 Set of Stellite Tools Turned	5,750 Pieces in 1,030 Hrs.
3¼ Sets of the Other Tools Turned	5,750 Pieces in 1,453 Hrs.
Number of Hours Saved by Investing in One Set of Stellite Tools	423 Hrs.

Tell us of *Your Job* and we will tell you of the increased production *You Can Get* and *How to Get It*

HAYNES STELLITE
CUTTING TOOLS

HAYNES STELLITE COMPANY

Carbide and Carbon Building—30 East 42d Street, New York

Peoples Gas Building, Chicago General Motors Building, Detroit 4503 Euclid Avenue, Cleveland

Anderson Six
Auburn Six
Barley Six
Cadillac Eight
Case Six
Chalmers Six
Chandler Six
Cleveland Six
Columbia Six
Crawford Six
Davis Six
Essex Four
Flint Six
Fox Six
Hupmobile Four
Hudson Six
Jordan Six
Lafayette Eight
Lincoln Eight
Moon Six
National Six
Northway Four
Oakland Six
Packard Single Six
Packard Twin Six
Rickenbacker Six
Stearns Four
Stearns Six
Saxon Four
Sterling-Knight Six
Studebaker Light Six
Star Four
Templar Four
Winton Six
Continental Motors

Where Engineers Agree

Automotive Engineers work under widely differing conditions. Not all of them seek exactly the same goal. Variety of training and experience naturally leads to differences in their recommendations.

But on some points there is notable agreement between them. Their preference for Morse Silent Chain, for instance, has established our equipment as the dominant form of cam and accessory drive.

A glance at the list of Morse equipped cars shows how pronounced is this preference.

MORSE CHAIN COMPANY

Main Office and Works
ITHACA, NEW YORK

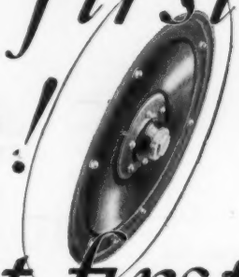
Sales and Engineering Office
DETROIT, MICHIGAN

THE CONSTANT PRESSURE ANGLE CHAIN

MORSE

GENUINE SILENT CHAIN

Wheels are the first moving parts seen!



Strengthen that first impression with Tuarc, Disteel or Forsyth, the prevailing steel wheels.

MOTOR WHEEL CORPORATION *LANSING, MICHIGAN*

Wood Wheels · Steel Wheels · Stampings

Tuarc-Disteel-Forsyth

Motor Wheel
PRODUCTS

Ride in Cushioned Comfort

No matter how rough and uneven the road, how long and tiresome the trip, the baby, cradled in his mother's arms, knows neither shock nor fatigue. This is because the mother automatically absorbs the shocks and cushions the child against them with the springy resiliency of her arms.

This same ease and freedom from uncomfortable motor travel will be yours if you equip your car with Hoo-Dyes, for they act on the same principle as mother's arms. This hydraulic spring control compels your car to ride on liquid cushions, and by eliminating the bumps and shocks due to uneven roads makes every mile a mile of cushioned ease.

There is no car so finely made or beautifully balanced that it does not need the cushioned comfort of Hoo-Dye hydraulic control. Hoo-Dyes have brought a new delight to motoring by wiping out all road fatigue.

THE HOUDAILLE COMPANY, 1410 West Ave., Buffalo, N. Y.
Houde Eng. Corp., M'fr's

Standard Equipment in

Europe	*America*
Alda	Lincolns
Aries	Cunninghams
The Austin Motor Co., Ltd.	Mercers
de Bazelaire	while many thousands
Chenard & Walker	have been applied to
Delage	Cadillacs
Delaunay-Belleville	Locomobiles
Delahaye	Pierce-Arrows
D. F. P.	Lafayettes
Farman	Packards
G. Irat	Studebakers
La Colombe	Hudsons
Minerva	Buicks
Philos	and many other
Rochet Schneider	makes.
Scap	
Slim	
Secqueville & Hoyau	
Unic	
Wolseley Motors Ltd.	

For your own health's sake, send for a copy of "How Motor Shocks Affect the Nervous System," by R. Kendrick Smith, M.D.

HOO-DYE
Shock Absorbers
Hydraulic

Positive Proof of Consistent Dependability

QUALITY SNAP RINGS

NOV. 30, 1911

DEC. 1, 1912

JUNE. 15, 1915

SEPT. 1, 1916

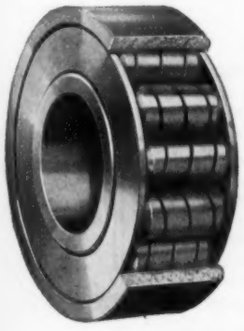
SEPT. 1, 1920

April 1, 1923. Ground broken for $250,000 foundry building. Electric furnaces and special equipment will be installed, designed for a production of over 20,000 piston ring castings per hour. When completed this will be, without question, the most modern and efficient piston ring foundry in the world.

The Piston Ring Company

Muskegon, Michigan

HYATT
Quiet
Roller Bearings



The many engineering refinements that are embodied in the new Gardner are the outcome of the earnest desire of its manufacturers to provide a still greater dependability and economy.

Realizing the many advantages that follow the use of Hyatt roller bearings, Gardner engineers specified these bearings in the rear axle construction.

By carrying the gear load at the differential and the car's weight at the hubs Hyatt roller bearings help to assure for Gardner owners a rugged, quiet, trouble-proof rear axle.

HYATT ROLLER BEARING COMPANY
Newark Detroit Chicago San Francisco

Worcester Milwaukee Huntington, W. Va. Minneapolis Philadelphia
Cleveland Pittsburgh Buffalo Indianapolis

AGATHON ALLOY STEELS

THE average motor car owner little understands or appreciates the tremendous stresses and strains to which the vital parts of his car are subjected while speeding over country roads—up hill and down vale. He has little conception of the grating, grinding, wearing effect of steel upon steel that takes place in axle housing, transmission case and under the hood of his car.

But the car builder knows. And in seventy to eighty of the highly stressed parts of his car he uses nothing but super-steels—alloy steels of such analysis as will best resist wear, shock and strains.

In most of America's best known cars these vital parts are made of one of the many analyses of Agathon Alloy Steels. Each is produced to meet precise requirements. Charts showing analysis and physical properties of nineteen popular alloy steels are given in our booklet, "Agathon Alloy Steels," which will be sent on request.

We have daily production in all kinds of commercial alloy steels such as—

Nickel, Chrome-Nickel, Uma, Molybdenum, Chrome-Molybdenum, Nickel-Molybdenum, Vanadium, Chrome-Vanadium, Chromium, etc.

Deliveries in Blooms, Billets, Slabs, Bars, Spring Flats, Hot Rolled Strips, etc.

THE CENTRAL STEEL COMPANY, Massillon, Ohio

SWETLAND BLDG. CLEVELAND | BOOK BLDG. DETROIT | PEOPLES GAS BLDG. CHICAGO | UNIVERSITY BLOCK SYRACUSE | WIDENER BLDG. PHILADELPHIA

A Stage-Coach of Today

—with a record of over 300,000 miles of continuous service

Modern successors of the old stage-coaches of '49, sturdy, Delco-equipped Cadillacs today are carrying passengers over plains, deserts and mountain roads.

Day after day, year after year, one of these cars belonging to a fleet of Cadillacs owned by the Red Star Stage Company of San Francisco has made its trips to Half Moon Bay and Pescadero.

It has rendered more than 300,000 miles of this type of service—a distance equal to twelve times around the world.

This performance is but one of many extraordinary demonstrations of the dependability and endurance of Delco —the World's Foremost Starting, Lighting and Ignition System.

Ever since 1911 when Cadillac introduced to the motor car industry the first complete electrical system—Delco, this pioneer electrical equipment has been used on millions of high-grade motor cars where quality and performance are the manufacturer's only ideals.

DAYTON ENGINEERING LABORATORIES COMPANY
DAYTON, OHIO

Delco

STARTING LIGHTING IGNITION
DELCO
THE DAYTON ENGINEERING LABORATORIES CO.
DAYTON, OHIO

Multiple Disc Clutches.

"DETLAFF"

HOW many engineers know that the Detlaff Model "H" multiple disc clutch is the commercial refinement of the famous U. S. Standardized Class "B" clutch — designed by a coterie of America's foremost engineers?

CUSTOMERS tell us our Model "H" is the most *dependable* clutch on the market. The "VELVET CLUTCH WITH THE BULL-DOG GRIP" is specified on trucks, for instance, destined for out-of-the-way foreign points, where difficulties of Service, or lack of any Service, compel the use of only those units with proven long life records.

THE friction elements are interchangeable for U. S. Standardized Class "B" and Detlaff Model "H." Distributing depots for parts are located in London, Eng.; New York, Baltimore, Chicago and San Francisco.

A. J. DETLAFF CO.

Detroit, Mich.

S. A. E. Employment Service

The following announcements are published for the benefit of members of the Society and the convenience of companies in need of men. No charge whatever is made for this service. In the case of items prefixed by an asterisk further information is withheld at the request of the company or individual making the insertion, but written communications bearing the number of such items will be forwarded by the office of the Society. Applications for positions from non-members must be endorsed by a member of the Society.

No announcement will be repeated in these columns unless specific information is at hand that the respective member is available or the position unfilled.

To put available men and employers in touch with each other quickly, this column is supplemented twice weekly by a bulletin giving the latest information with regard to Men and Positions Available. The bulletin will be mailed to members and employers on request.

It is suggested that for quick action in securing men or positions there be specified for publication the name and address, a post-office box number or a general mail delivery address. If applications are confidential, the Society will forward replies through an index number.

For the good of the service members securing or filling positions or companies securing men through these columns are urged to send advices to this effect to the office of the Society promptly.

Considerable time can be saved in securing a position if the following items of information are given in registering with S. A. E. Employment Service.

1. Date
2. Name in full
3. Present mail address
4. Telephone number
5. Present telegraph address
6. Permanent mail address
7. Telephone number
8. Married or single
9. Nationality
10. Age
11. Height
12. Weight
13. State of health
14. Education (Give schools and colleges attended, courses taken and duration of each course)
15. Previous employers (Give names, addresses, term of employment with each, your title and the nature of the work done)
16. Are you employed at present?
17. References (Give names and address of three or four persons not related to you and with whom you have been directly associated)
18. What societies, clubs or associations are you a member of?
19. Salary wanted per week, month, year
20. What general classifications do you wish to be listed under? (List in order of preference. For example: General Manager, Works Manager, Research Engineer, Production Engineer, etc.)
21. Do you wish your name and address published in your announcement?
22. Do you wish to use a post-office box number? (If so, arrange with your postmaster for the use of a box and send the number of the box to us, giving town and state)
23. Is your name to be withheld from publication? (In this case your announcement will be run under an index number and replies will be forwarded through the office of the Society)
24. Prepare copy for insertion in THE JOURNAL and Bulletin. (Make it as complete and as concise as possible)
25. Any preference as to location?
26. When will you be available?

MEN AVAILABLE

0942 CHIEF INSPECTOR, CHIEF DRAFTSMAN OR ASSISTANT ENGINEER; 15 years' experience with prominent automotive companies. Technical graduate. Experimental work. Residence, Detroit; location, Middle West preferred.

0987 CONSULTING AND DESIGNING ENGINEER Graduate of Cornell University in electrical and mechanical engineering with 20 years' experience in stationary, automobile and Diesel engines, design and production, jigs, etc., wishes work in inventing, developing or design, either at his home or in reach of Larchmont, N. Y.

0988 ENGINEER Technical and practical man who has made a specialty of engine governors desires to make a connection as assistant chief engineer or suitable executive post. Residence New York City: location, immaterial.

(*Continued on p. 70*)

A New Ease to Car Operation

Clutch performance plays a most important part in car operation. Easy, silent and effortless gear shifting depends largely upon clutch action—it is the clutch which governs the smoothness, quietness and agility with which the motive power is transmitted to the driving shaft.

The Long Clutch brings a new ease to car operation because it provides these essentials in a degree never before attained. When operating a car equipped with the Long Clutch, the driver need never know the embarrassment and confusion of clashing, grinding gears. Engagement takes place with a gliding motion in which all tendency to jerk or grab is eliminated. Moreover, this goodness is permanent, for the Long Clutch never needs adjustment.

Long Manufacturing Co., Detroit, Mich.

LONG CLUTCH

LONG PRODUCTS—RADIATORS AND CLUTCHES

The
Pictures
Tell
The Story

The
Highland
Model D
Cab
Meets Every
Trucking
Condition

THE
HIGHLAND
BODY MFG. CO.
410 Elmwood Place
Cincinnati,
Ohio

S. A. E. Employment Service

Continued

MEN AVAILABLE

1036 Automotive Engineer; practical and technical education; 20 years' experience in designing, production, research, testing, consulting and teaching; part time if desired; high-grade man capable of getting results. Residence, New York City; location, New York City or vicinity preferred.

1039 Assistant to Executive; university graduate with 6 years' experience with motor car builders; competent to take charge of service work, purchases and stores stock, and to assist in engineering. Residence, New York City; location, New York City or vicinity preferred.

1083 Engineer who has had 10 years' experience on Diesel engines and has designed and built complete line with 30,000 hp. now in operation wishes to establish a connection with an engine builder. Residence, Cleveland; location, immaterial.

1096 Production Manager and Mechanical Engineer would consider a position requiring initiative and ability to handle production engineering problems successfully. 12 years' executive experience in automotive and allied industries; supporting testimony available. Residence, Brooklyn; location, New York City or vicinity.

1102 Engineer; truck and truck fleet operation; would prefer a position in commercial research or sales development. Technical training. Factory sales work or pioneering of a new product. Residence, Pittsburgh; location, New York City or vicinity preferred.

1174 Manager of Sales, District Manager or Sales Engineer. Technical graduate with 12 years' shop, sales office and sales engineering experience on the road. Experienced in specialty products applicable to automotive industry. Residence, Philadelphia; location, Philadelphia only.

1180 Chief Inspector; technical education; 11 years' executive experience with prominent gas and automobile engine builders. Capable of supervising, organizing, systematizing and tooling inspection efficiently and diplomatically from the foundry to the test stand. Residence, Indiana; location, immaterial.

1185 Research or Chief Engineer, General or Production Manager; wide experience with prominent companies. Also airplane experience. Residence, Long Island; location, New York City or vicinity.

1206 Production Manager; 10 years' association with prominent manufacturers of metal and wood products. Extensive supervisory experience in machinery construction, also quantity production involving repetition operations of metal products. Practical man and capable organizer and administrator with college and practical training. Residence, New York City; location, immaterial.

1208 Designing Engineer; 5 years' experience on passenger cars, trucks, engines and railroad air brakes as chief draftsman, also some experimental experience. Residence, New York City; location, New York City or vicinity.

1217 Chief or Executive Engineer. Technical graduate with 12 years' experience in automobile engineering; especially versed in eight-cylinder design with successful experience in chassis and body design. Has made a thorough study of cost reduction in manufacturing from engineering standpoint and is experienced in complete car development from the experimental stage to production. Residence, Indianapolis; location, immaterial.

1219 Chief Engineer of large corporation building Diesel and automotive engines and steam turbines for 8 years, desires a position with a company having a research department that would like to develop high-speed Diesel engines for automobiles and tractors. Residence, Iowa.

1220 Engineer who was formerly with a large tractor builder in Ohio in an experimental and drafting capacity desires a similar position with an automobile or engine company. Wide experience with high-speed type engines. Residence, Ohio; California or other Western States preferred.

(*Continued on p.* 72)

See announcement at the head of the S. A. E. Employment Service column, p. 68.

ROSS
Cam & Lever Steering Gear
Patent Pending

Lower end of gear, with side of housing removed, showing lever in mid-position on the cam.

Inside view of side of housing, showing end of trunnion shaft lever arm and diamond stud, with arc of lever action.

Housing entirely removed, showing variable pitch of the thread of the cam and relation of cam and lever in mid-position.

Cam and lever in extreme position, showing the swing of the steering arm. Variable pitch of cam also plainly shown.

This new steering gear is so radically different in principle and design that many engineers were frankly skeptical about our claims for it. However, demonstrations have convinced them and they are now enthusiastic over this wonderful combination of small size and simple construction with power, reliability and easy steering.

The gear is so irreversible in mid-position that practically all road shock is eliminated. The long lever arm inside the gear provides the easiest kind of steering under all conditions and the car holds the road with the least effort on the part of the driver.

The variable pitch of the cam offers a unique accelerated action which facilitates quick handling in making turns and in swinging back into flat-to-the-curb parking position.

Adapted for passenger cars, motor trucks, motor buses, fire trucks and tractors. Write for special information desired.

ROSS GEAR & TOOL COMPANY
730 Heath St., Lafayette, Indiana, U.S.A.

ROSS STEERING GEARS

THE STEERING GEARS THAT PREDOMINATE ON MOTOR TRUCKS

Deppé Motors Corporation Superheated Gas System

(Patented)

This system in cars of the 3000 lb. class with engine displacement of 250 cubic inches gives results as follows:

With 100 lb. Compression

Fixed Superheated Gas Mixture

Fixed Adjustments in All Parts with Controlled Combustion

Develop maximum speed of 60 M.P.H.

Twenty-two miles per gallon with existing or any future motor fuels.

Sixteen hundred miles per gallon of lubricant.

Ten to 30 M.P.H. in 9 seconds.

Radiator water normally around 130° F.

NO THERMOSTATS

Easy starting, no loading.

Practically eliminates carbonization.

No preignition, no autoignition.

No so-called detonations.

Eliminates vibration due to fuel conditions.

Practically eliminates lubricating oil dilution.

No overheating of metals.

Practically eliminates valve grinding.

Practically eliminates bearing adjustments.

Practically eliminates spark-plug troubles.

PRACTICALLY ELIMINATES GEAR SHIFTING.

Deppé Motors Corporation

151 Church Street

New York City

S. A. E. Employment Service

Continued

MEN AVAILABLE

1229 Automotive Engineer; Cornell graduate with 8 years' experience in the design and development of engines and automobiles; now chief engineer of Eastern company but wishes to make a change; responsible executive position desired. Available on reasonable notice. Residence, Connecticut; location, East or Middle West preferred.

1230 Automotive Engineer; Engineering executive with a technical education and 12 years' experience in the original design of complete cars and factory methods desires a position with a car, engine or parts manufacturer, or as sales engineer. Residence, Cleveland; location, immaterial.

1231 Assistant Engineer or Chief Draftsman; 6 years' experience; thoroughly familiar with the design, construction and production of motor trucks. Available in 2 weeks. Residence, Pennsylvania; location, immaterial.

1232 Instructor with several years' experience in practical work wishes a position in an engineering college as instructor in some line of automotive or transportation work. Residence, Illinois; location, Central West.

1233 Sales Manager now located in Detroit and possessing a wide acquaintance among automobile companies, desires to supervise sales or act as a district representative for a parts manufacturer. Residence, Detroit; location, Middle West preferred.

1235 Service Manager; high-grade man with experience in service merchandising methods; stock and shop arrangement and management. Graduate mechanical engineer with 10 years' experience in truck maintenance and service work. Residence, suburb of New York City; location, New York City.

1246 Factory Manager, Production Engineer, Superintendent or Sales Engineer; technical graduate; 17 years' executive experience with mechanical and electrical accessories including storage-batteries. Capable organizer. Familiar with modern manufacturing and cost methods. Residence, New Jersey; location, immaterial.

1247 Retail Sales Executive; University graduate, aged 34, with extensive experience in service, sales and sales promotion, seeks a broader opportunity with location in New England. Present yearly earnings are in excess of $6,000 as manager of a branch doing a large volume of business. Has introduced and developed successful sales plans.

1250 Executive with organization ability assuring a quality product at a minimum cost; leadership that inspires loyalty, harmony and confidence; 17 years' experience in varied industries; 11 years with an exclusive automobile company. Excellent references. Residence, Buffalo; location, northern United States.

1251 Automotive Engineer Technical graduate with 20 years' continuous experience on the board and as a supervisor of machine and tool design, wishes a position as chief or assistant chief engineer, chief tool designer or master mechanic. Residence, Chicago; location, Middle West.

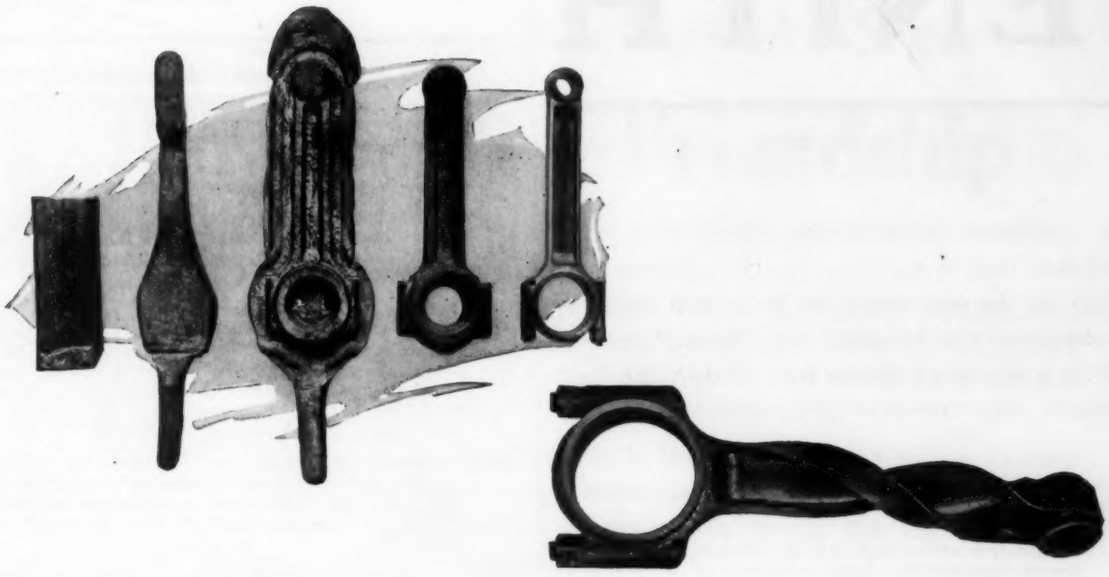
1255 Sales Executive with 19 years' engineering and sales experience in automotive industry who is now sales manager, desires to make a change for personal reasons. Competent to handle national sales and advertising of engines, motorbuses or any parts, or accessories on passenger cars, trucks or tractors; available in two weeks. Residence, Middle West; location, immaterial.

1257 Mechanical Engineer 29 years old and experienced in production and design wishes a position in the production department of a company manufacturing transmissions and differentials. Residence, Pittsburgh; location, immaterial.

1258 Engineer, has held responsible positions as tool designer, research, engine designer, production, sales engineer and consulting engineer. Residence, Ohio; location, Cleveland preferred.

(*Continued on p. 74*)

See announcement at the head of the S. A. E. Employment Service column, p. 68.



Forgeability, Machineability and Toughness of Vanadium Steel

THE Curtiss Airplane Connecting Rod, of which approximately 150,000 were furnished for Curtiss OX airplane engines, affords an excellent illustration of the forgeability, machineability and toughness of Vanadium Steel.

Note the unretouched photographs of progressive stages in the production of this well-known connecting rod.

The finished rod was twisted cold to prove the remarkable toughness of Vanadium Steel.

This distorted connecting rod has the following physical properties:

Elastic limit	125,000 lbs. per sq. in.
Tensile strength	138,000 lbs. per sq. in.
Elongation in 2"	20%
Reduction of area	64%

For every steel purpose demanding exceptional strength, toughness and machineability, there is a Vanadium Steel. Our Metallurgical Engineers will be glad to help you study the problem and select a better steel for your purposes.

VANADIUM CORPORATION OF AMERICA
New York, 120 Broadway Detroit, Book Building

VANADIUM STEELS

for Strength, Toughness and Durability

ZENITH

"The question of saving gasoline should be accomplished, first, by knowing that the carburetor is right for the particular truck and that if any adjustments are to be made, that they will be made by a capable carburetor man. *Better still, if possible, use a non-adjustable carburetor.*"

(Extract from address made by E. E. LaSchum, General Superintendent, American Railway Express Company, before Seventh Annual Convention, International Retail Druggists Association.)

Over 160 American Automotive Manufacturers have solved this problem by adopting Zenith Carburetors, because, when the proper jets have been chosen to give the best performance, *they become fixed parts of the carburetor, not subject to outside manipulation.*

ZENITH - DETROIT CORPORATION

Manufacturer of

ZENITH CARURETORS

DETROIT, MICHIGAN

Branches: New York—Cleveland—Chicago

S. A. E. EMPLOYMENT SERVICE

Continued

MEN AVAILABLE

1260 TECHNICAL GRADUATE, has held positions of assistant chief engineer, assistant production manager; domestic and foreign experience on water and air-cooled engines, airplanes and motorcycles; also experimental work and sales. Residence, New York City; location, immaterial.

1262 METALLURGICAL ENGINEER, able to take full charge of laboratories and production or as factory manager in plants making hardened steel parts. Residence, New Jersey; location, immaterial.

1263 SERVICE ENGINEER; over 16 years' experience in all departments as executive, organizer and efficiency expert in passenger-car and truck details; experienced in promotion work, the standardization of service-station equipment and methods, the installation of flat-price cost system on repairs, etc.; truck factory organization experience. Residence, New York City; location, immaterial.

1264 DESIGNING AND RESEARCH ENGINEER; 11 years' experience on four and six-cylinder truck and automobile engines; has held positions of chief and experimental engineer; technical education. Residence, Wisconsin; location, Middle West preferred.

1266 AUTOMOTIVE ENGINEER with 20 years' experience and capable of taking complete charge of engineering department, engines or complete chassis. Wishes position offering proper opportunities. Reliable, energetic, and has initiative. Residence, Rochester.

1271 HIGH-GRADE AUTOMOTIVE ENGINEER with a broad and successful record in engineering, manufacturing and factory organization; a pioneer in the automobile, truck and tractor industries. Residence, Western United States.

1272 YOUNG GRADUATE MECHANICAL ENGINEER with 4 years' experience in service work and 9 months as instructor in automobile mechanics, desires to establish a connection with an automobile company in a production or engineering capacity. Willing to start with modest salary. Residence, Missouri; location, immaterial.

1273 TECHNICAL MAN, 25 years old who will graduate this year in automotive engineering and has had 2½ years' experience in automobile service-station and machine-shop work wishes to locate in engineering or factory service department. Residence, Atlanta; location, immaterial.

1275 ENGINEER with many years' experience and an extensive acquaintance among engineering executives wishes to represent in the Chicago territory the manufacturer of high-grade automotive product that must be backed by a responsible producer and publicity promoted by adequate advertising and sold to jobbers or quantity users. Residence, Chicago.

1280 ENGINEER OR SALES EXECUTIVE; 20 years' experience in the design, construction and sale of vehicles of various types and accessories; wide acquaintance in industry; excellent references; part or entire time; has engineering office in East at present; has specialized in the development of new machines and parts; compensation proportional to results. Residence, Pennsylvania; location, East preferred.

1281 CHIEF RESEARCH OR PRODUCTION ENGINEER OR CHIEF INSPECTOR; wide general mechanical engineering experience; automotive work a specialty in the maintenance and repair of a large fleet of tanks, trucks and automobiles; is an expert research engineer, with the ability to test all kinds of vehicles and possesses a sound knowledge of factory organization and inspection methods; also an expert designer of engines; is tactful with labor, a good mixer and ambitious. Residence, New York City; location, immaterial.

1283 EXECUTIVE; successful record in the manufacture of tools and automotive parts on a large scale; specialty, maximum quality production at a minimum cost; best of references. Residence, Illinois; location, Chicago or vicinity preferred.

(*Continued on p.* 76)

See announcement at the head of the S. A. E. Employment Service column, p. 68.

STORAGE BATTERY
Willard
SERVICE STATION

1 T. A. Willard—who has done and is doing more for storage battery improvement than any other one individual.
2 The Willard Organization—for fifteen years leaders in storage battery manufacture and distribution.
3 The Willard Laboratories—physical, chemical, mechanical and electrical—the finest equipment for battery research in the country.
4 The Willard Factory—with the size, resources and volume for quantity production to a high quality standard.
5 Original Equipment on 135 makes of motor cars; 93% have always used Willard Batteries.
6 The Friendship of 20,000 car dealers.
7 The Good Will of 10,000,000 car owners.
8 The leading Wood-Insulated Battery.
9 The only Threaded Rubber Battery.
10 The most extensive and long-continued and consistent national advertising.
11 The most efficient co-operation with the dealer's local advertising.
12 Membership in the original and most efficient national battery service to car owners.

Back of the Sign

6—Friendship

We can truly say the car dealers of the country are our friends.

They send their owners to Willard Service Stations because they know that Willard Dealers will give them the kind of service which they should have.

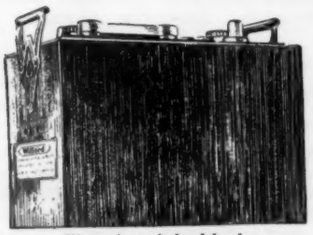
They believe in Willard because they see at first hand the performance of Willard Threaded Rubber Batteries on their cars or on the cars of their neighboring dealers.

And they know from past experience that the Willard Dealer must first, foremost and all the time make good with the owners of Willard Batteries, and the dealers who sell Willard equipped cars.

This is a standardized, organized, efficient service cheerfully rendered to any dealer or owner no matter what make of battery he has.

WILLARD STORAGE BATTERY CO., Cleveland, O.
Made in Canada by the
Willard Storage Battery Co. of Canada, Limited, Toronto, Ontario

Willard STORAGE BATTERIES



The acknowledged leader of wood-separator batteries for fifteen years.

Original Equipment on 135 Makes of Motor Cars

The Threaded Rubber Battery that created a new standard of battery value.

MATHER SPRINGS

Standard of the World

The shortest cut to getting your full money's worth in the things you buy is—Quality.

Genuine Made Only By

The Mather Spring Co.

Toledo, Ohio, U. S. A.

S. A. E. EMPLOYMENT SERVICE

Continued

MEN AVAILABLE

1284 CHASSIS ENGINEER, DESIGNER, OR CHIEF DRAFTSMAN; 12 years' experience in designing chassis, engines, axles and transmissions; also in production; has been connected with some of the most prominent passenger-car companies as assistant engineer, chassis engineer and chief draftsman. Residence, New Jersey; location, immaterial.

1286 ASSISTANT TO CHIEF EXECUTIVE, SALES OR PRODUCTION ENGINEER; man with a wide general mechanical engineering experience in the United States and Europe, technical training, experience in the automotive and allied industries, and electrical experience, desires position with car, engine or parts manufacturer. Would represent firm in Europe or the East. Residence, New York City.

1291 WORKS MANAGER, OR ASSISTANT TO EXECUTIVE; engineering graduate; experience covers entire automotive field; possesses a sound knowledge of factory administration, corporation law and finance; is a capable organizer and administrator with practical training of modern manufacturing methods and labor management. Residence, New York City; location, immaterial.

1292 SALES MANAGER; 16 years' experience in the automotive field; technical education; wide advertising experience, sales promotion, efficient modern merchandising methods; can take entire charge of accessory proposition if desired, or render valuable constructive assistance. Residence, New York City; location, immaterial.

1293 LUBRICATION ENGINEER with 10 years' experience in calling on automotive manufacturers is open for immediate proposition. Residence, Toledo; location, Middle West preferred.

1294 RESEARCH OR SALES ENGINEER; wide experience; has been with prominent automotive companies in research, experimental and dynamometer work; college education. Residence, Ohio; location, immaterial.

1295 AUTOMOTIVE ENGINEER; thorough technical education; 10 years' practical experience as designer and executive in charge of design; resourceful, thorough and diplomatic and possesses the ability to get desired cooperation from other departments. Residence, Philadelphia; location, immaterial.

1303 MECHANICAL ENGINEER; technical graduate with 10 years' experience in developing processes, production methods and plant layouts for manufacturers of interchangeable parts, machine tools and wood products, is now available. Residence, New Jersey; location, Eastern States or abroad.

1305 FACTORY MANAGER, CHIEF ENGINEER, OR PRODUCTION MANAGER; technical graduate; 15 years' successful experience in the management and engineering of industrial plants producing high-grade interchangeable parts. Available on short notice. Residence, Connecticut; location, southern New England, eastern New York or New Jersey preferred.

1306 ASSISTANT CHIEF ENGINEER; 10 years' executive and designing experience; thoroughly familiar with the design and construction of complete passenger cars, trucks and engines. Residence, Chicago.

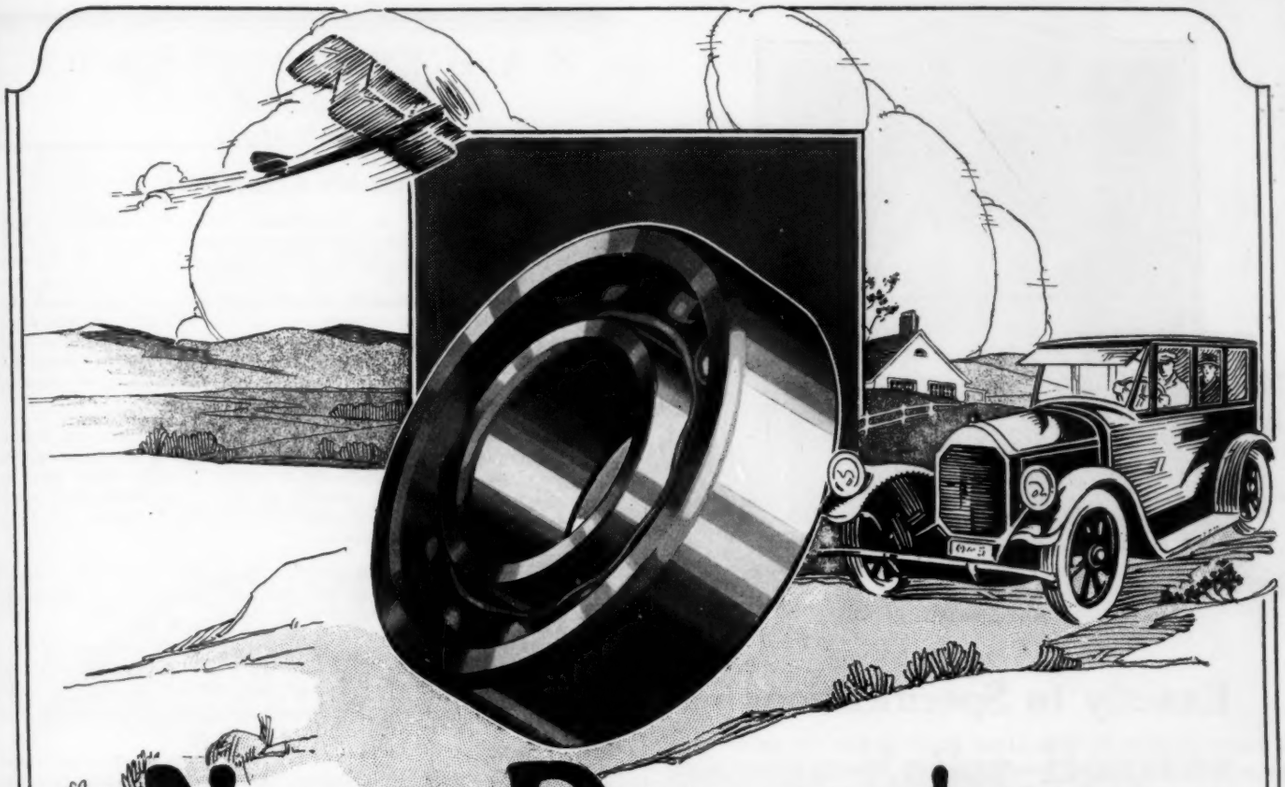
1310 BODY ENGINEER; Graduate mechanical engineer with wide experience in high-grade custom body and quantity production, including closed and open bodies; also taxicabs; closed bodies preferred; acting in consulting capacity at present; highest references. Residence, Chicago; location, immaterial.

1311 TRANSPORTATION MANAGER OR RESEARCH ENGINEER in tractor factory; several years' experience as instructor and production engineer. Residence, Chicago; location, Middle West preferred, but not essential.

1312 GAGE ENGINEER, CHIEF INSPECTOR, executive, with unusual scientific and manufacturing experience covering 12 years, desires a position of responsibility. Has large engineering acquaintance from accomplishments, technical writings and personal contact. Residence, New England; location, immaterial.

(*Continued on p.* 78)

See announcement at the head of the S. A. E. Employment Service column, p. 68.



New Departure Ball Bearings

New Departures Simplify Maintenance

More than ever, motor vehicles are bought with an eye to the probable upkeep expense. Because they know that the labor to "get at" a part is often more than the cost of that new part, buyers are willing to pay more for a car or truck whose parts are known to have long life.

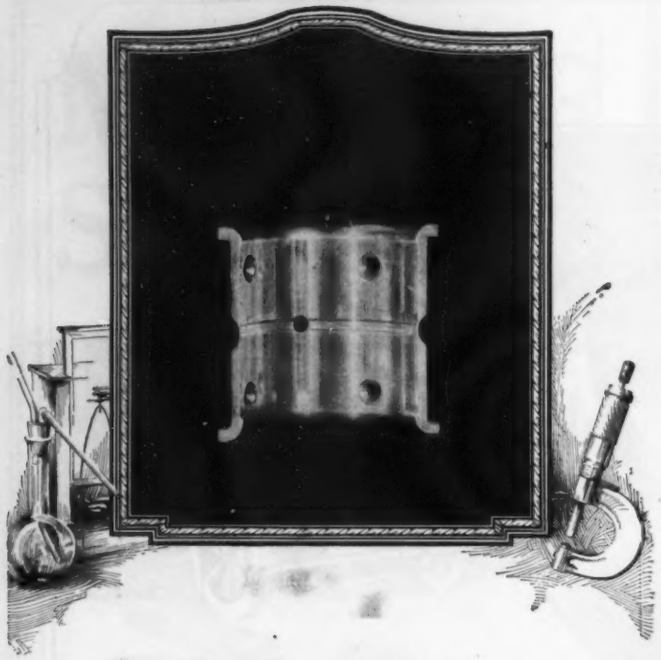
This also applies, in proportion, to parts which must be adjusted.

New Departure ball bearings last as long as the vehicle itself, for three reasons—correct principle, finest bearing steels, exquisite accuracy of dimension and finish. And this long life eliminates the necessity for adjustability.

THE NEW DEPARTURE MANUFACTURING CO.

BRISTOL, CONN.

CHICAGO **DETROIT**



Exactly to Specifications

The buyer of Hoyt Babbitt-Lined Bearings has the positive assurance that the finished product will be exactly to his specifications. If he orders S. A. E. No. 11 babbitt, he will get exactly that—if he orders bronze or babbitt to his own particular specifications he will get precisely the composition that he specifies.

Used by Prominent Motor Builders

Hoyt Babbitt-Lined Bearings are used by some of the foremost motor builders in the United States—they know that Hoyt bearings go far toward maintaining a reputation for uniform reliability of their product throughout a period of unusually long service. Send for 24-page book on Babbitt-lined Bronze Bearings.

HOYT METAL COMPANY

Boatmen's Bank Bldg., St. Louis, Mo.

New York Chicago Detroit Toronto London

Other Hoyt Products

Bronze-backed Babbitt-lined Bearings and Bushings.
All-bronze Bushings.
Stick Bronze, Cored or Solid.
Brass and Aluminum Castings.
Rolling Mill Bearings.
Babbitt Metals.
Die Castings of Zinc Base, Tin Base and Special Alloys.
Sheet Block Tin.
Tin Pipe.
Lead Pipe.
Special Casting Metals.
Sheet Lead.
Lead Washers.
Tape Lead.
Lead Sleeves.
Lead Wool.
Lead Wire.
White Copper Stamping Metal.
Casting Metals.
Solder (bar and wire.)

Established 1873

HOYT

Bronze-Backed Bearings

S. A. E. EMPLOYMENT SERVICE

Continued

MEN AVAILABLE

1313 GENERAL SALES OR ADVERTISING MANAGER; graduate electrical engineer who has taken post-graduate work in business administraton and has a successful record in the sale and advertising of several mechanical products; can take charge of established products or develop new ones for manufacturers or dealers and render valuable assistance in perfecting design and standardizing products; handles men successfully and coordinates inter-departmental relations. Available July 1. Residence, Ohio; location, Los Angeles or New York City preferred.

1318 CHIEF ENGINEER, WORKS MANAGER, PRODUCTION OR TECHNICAL SERVICE ENGINEER Traveling road man with experience in design, experimental work, pattern shop and inspection department wishes to get into production work or engineering and production combined. Residence, Indiana; location, immaterial.

1319 PRODUCTION ENGINEER, WORKS MANAGER; 6 years' experience in woodworking and rubber industries. Residence, Philadelphia; location, East preferred.

1320 SUPERINTENDENT; in charge of fleet of 60 commercial and light automobiles for passenger and haulage service, including Pierce-Arrow, Peerless, Albions, etc.; has also worked in machine, fitting and body shops and power station. Residence, England; location, immaterial.

1322 DETAIL DRAFTSMAN; available now; 3 years' experience and 2 years' technical training. Residence, Illinois; location, immaterial.

1323 EXPORT MANAGER, EXECUTIVE; 15 years' experience with prominent companies and several years as sales manager for Eastern territories; speaks five languages fluently and has traveled all over the world; best of references. Residence, Germany; location, immaterial.

1324 MECHANICAL ENGINEER; technical graduate with experience in shop, toolroom, inspection, tool design and development and aviation engines: airplane work a specialty. Residence, New York City suburb; location, New York vicinity preferred but not essential.

1327 EXPERIMENTAL ENGINEER, INSPECTION MAN; 15 years' engineering experience including field research inspection. Residence, Utah; location, West preferred.

1328 CHIEF OR DESIGNING ENGINEER; 14 years' experience in the design of air-cooled engines, complete cars and all units, including 5 years in office of chief engineer. Residence, Ohio; location, Ohio or farther East.

1329 SERVICE MANAGER Capable aggressive executive who possesses the ability to organize an effective department and has made an intensive study of all phases of passenger and truck service problems, and has been associated with two of the leading automobile companies. College graduate. Residence, Cleveland; location, immaterial.

1330 FACTORY MANAGER, CHIEF ENGINEER Man who is now with one of the largest passenger-car builders in the East desires to make a connection of similar capacity in Ohio, Indiana or Michigan with well-established firm. Available at an early date. Residence, Ohio.

1332 METALLURGICAL ENGINEER; technical graduate with 6 years' experience and a practical and theoretical knowledge of heat-treatment and metallography of all ferrous and nonferrous alloys, also nonferrous foundry practice; capable of directing metallurgical laboratory, heat-treatment department or foundry; expert on pyrometry.

1333 WORKS MANAGER, OPERATING ENGINEER OR TECHNICAL REPRESENTATIVE; 17 years' automotive experience in the design and production of cars, commercial and battery vehicles and a production knowledge of Entz magnetic system; also lecturing experience; would represent leading American company in England; otherwise open to position in United States. Residence, London.

(*Continued on p.* 80)

See announcement at the head of the S. A. E. Employment Service column, p. 68.

TRANSMISSIONS
Unit Power
and
Main Frame

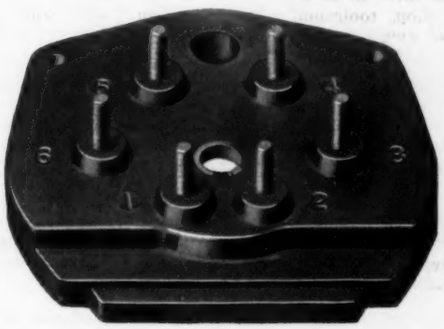
CLUTCHES
Multiple Disc
and
Multiple Lever, Single Plate

CONTROLS
A Style and Capacity
for
Every Requirement

BROWN-LIPE GEAR CO.

SYRACUSE, N. Y.

San Francisco Chicago Detroit
New York London, Eng.



The new plant of the International Insulating Corporation, now located at Elyria, Ohio, has been completed and is in production on gear shift lever balls, distributor heads, radiator caps, electrical connections, and all moulded parts, either from shellac composition or synthetic material, used on automobiles.

INTERNATIONAL INSULATING CORPORATION
ELYRIA - - OHIO

(Pat. and Pat. Pending)

Shafer Roller Bearing is Self-Aligning

The inner cone, being a true sphere, is free to tilt in all directions, making it automatically self-aligning.

It is an original combination of mechanical principles, having concave rollers set at an angle, traveling between a convex cup and cone. This construction makes it possible to absorb loads from any angle, either radial or thrust without pinching or binding.

Shafer Engineers Are At Your Service.

SHAFER BEARING CORP.
6501-99 West Grand Ave., Chicago, Ill.

SHAFER
Self-Aligning **ROLLER BEARING**

SERVICE FLOOD OILING FAN

"If It's a Flood Oiling Fan, It's a Service Fan"

Quiet operation after almost unbelievable mileage is the result of the flood oiled plain bearing which is a feature of Service Fans.

Thousands of miles can elapse before it is necessary to replenish the oil supply.

Service Fans have demonstrated their superiority on motor cars, trucks and tractors.

Technical data will be supplied on request.

Service Products Corporation
Indianapolis
Indiana

Put Your Cooling Problems Up to Us

S. A. E. EMPLOYMENT SERVICE
Continued

MEN AVAILABLE

1334 AERONAUTICAL LAYOUT ENGINEER. Technical graduate with 6 years' experience designing aircraft, including bombers and smaller metal construction, and recently in charge of body design including supervision of construction. Residence, Cleveland.

1338 RESEARCH AND DESIGNING ENGINEER; technically educated man in both mechanical and electrical lines who understands production methods thoroughly; can furnish best of references on sleeve and poppet-valve engines and chassis construction. Residence, New York City; location, New York City preferred.

1339 CHIEF ENGINEER, FACTORY MANAGER; thoroughly familiar with all engineering problems and factory management in the automotive industry; references available; now in Texas. Residence, Long Island; Eastern location preferred, but will go anywhere if inducement is sufficient.

1340 AUTOMOBILE FACTORY SUPERINTENDENT, WORKS MANAGER. Good executive with extensive experience in the assembling, body building, painting, trimming, enamelling and machine divisions wishes a position with a future. Residence, Canada; location, immaterial.

1343 EXECUTIVE ENGINEER; with 18 years' experience and who has held positions of assistant to president and chief engineer of some of the largest companies in the engineering field, and shown results that are recognized throughout the entire industry, would like to hear from high-grade organizations requiring his services, exceptional references; also European experience in accessories. Residence, New York; location, New York City preferred but not essential.

1344 RESEARCH AND DEVELOPMENT ENGINEER; extensive experience in developing new products and perfecting improvements in older ones; thoroughly competent in research technique and possessing resourceful engineering ability; automotive and oil engine work a specialty. Residence, Pennsylvania; location, Philadelphia or Metropolitan district.

1345 SERVICE MANAGER; 4 years' experience in passenger-car and truck service and sales; 8 years' cost and production; 4 years' export sales and service and 8 years' building passenger cars and trucks. Residence, Long Island; location, New York City preferred, but not essential.

1346 RESEARCH ENGINEER; 17 years' experience as foreman, chief inspector, passenger-car and truck testing; research engineer in passenger-car and truck design; can organize personnel; now employed. Residence, Indianapolis; location, Central States preferred.

1349 DESIGNING AND RESEARCH ENGINEER; graduate of European technical university who speaks English, French, German and Dutch; expert airplane-engine designer. Residence, Connecticut; location, immaterial.

1354 MECHANICAL ENGINEER; builder of high-class automobiles; development and research work; has had charge of assembly department of prominent automobile company. Address, J. Kaufman-Kawst, c/o S. A. E., 29 West 39th St., New York City

1355 TECHNICAL GRADUATE; age 24; with experimental laboratory and practical experience and a well-established knowledge of internal-combustion engine characteristics. Available in June. Residence, Kansas; location, immaterial.

POSITIONS AVAILABLE

544 SALESMAN wanted by a die-casting company in Pennsylvania.

545 ASSISTANT SALESMAN. Capable man is desired by a prominent company in Pennsylvania manufacturing aluminum, brass and bronze die castings.

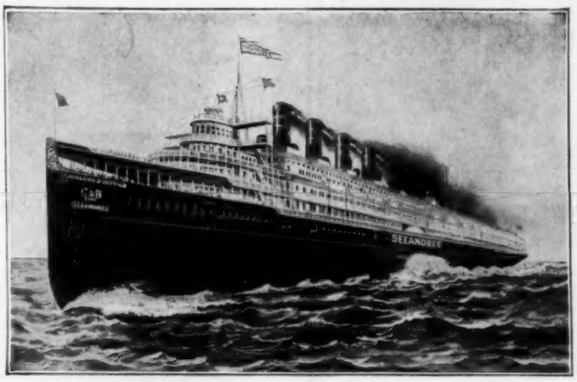
(*Continued on p.* 82)

See announcement at the head of the S. A. E. Employment Service column, p. 68.

Make Your Trip to Spring Lake More Enjoyable by a Refreshing Night on Lake Erie

Thousands of eastbound travelers say they wouldn't have missed that cool, comfortable night on one of our fine steamers. A good bed in a clean stateroom, a long, sound sleep and an appetizing breakfast in the morning! (And your car arrives on same steamer.)

C&B LINE



C&B LINE

The Great Ship "SEEANDBEE" and Steamers "City of Erie" and "City of Buffalo"

Daily, May 1 to November 15.

Leave Cleveland..... 9:00 p.m. Leave Buffalo..... 9:00 p.m.
Arrive Buffalo..... 7:30 a.m. Arrive Cleveland..... 7:30 a.m.

(Eastern Standard Time)

Fare: $5.50 One Way; $9.50 Round Trip

Tourist Automobile Rates (When accompanied by passengers)

	One way.	*Round trip.*
Cars 127 inches wheelbase or less.....	$10.00	$15.00
Cars over 127 inches wheelbase.....	14.50	24.00

All gasoline must be removed before cars can be accepted for shipment. Cars should be delivered to dock one hour prior to departure of steamer.

(Your rail ticket is good on the boats.)

THE CLEVELAND AND BUFFALO TRANSIT COMPANY

Cleveland, Ohio.
City office, 2051-3 E. 9th St.,
New Pier, ft. of E. 9th St.

Buffalo, N. Y.
City office, 16 E. Eagle St.,
Wharves, S. Michigan Ave. Bridge.

DAHLSTROM
Metal Mouldings & Shapes

DURABLE—ARTISTIC
Metal Instrument Panels

Dahlstrom metal instrument panels will not twist or warp. They are easily applied, and instrument openings are neat and carefully made.

Dahlstrom instrument panels are finished by our baked-on process in any color or graining desired.

DAHLSTROM METALLIC DOOR COMPANY

467 Buffalo Street, Jamestown, New York

PHILADELPHIA 305 Bulletin Bldg. DETROIT 501 Capitol Theatre Bldg. CHICAGO 19 So. LaSalle St.

Local representatives in principal cities.

The Highest Development of Vulcanized Cotton Fibre

IT has taken nearly a half a century to produce Vul-Cot Fibre—a half century of study and experiment to produce material of exceeding toughness and hardness and that is not brittle.

Vul-Cot is made by the oldest and largest manufacturer of Vulcanized Fibre in the country. Every detail, every process in the manufacturing of Vul-Cot Fibre is performed in the three huge plants of the National Vulcanized Fibre Company.

The result is a Fibre that is three times as tough as leather. No ordinary force can crush, break, crack or split it. Its tensile strength is from 9,000 to 14,000 pounds per square inch, with a resistance to shearing up to 13,000 pounds per square inch, and an electrical rupture up to 400 volts per Mil.

We have made Vul-Cot Fibre with such care, with such minute attention to every detail, that we can guarantee it to be free from impurities.

If there is a place for fibre in the composition of your product—if there is a possibility for a material that is as hard as horn, as durable as steel, as adaptable as rubber and yet less costly than any—we will gladly place at your disposal the experience gained through years of making parts for the products of the host of manufacturers who use Vul-Cot Fibre.

National
Vulcanized Fibre Company
Wilmington, Delaware

S. A. E. Employment Service
Continued

POSITIONS AVAILABLE

*575 Carbureter Sales Engineers to call on factories, make demonstrations, etc., are desired by old established factory in Middle West. Must be experienced, have technical training and good references.

*577 Sales Engineer for ball bearing company. Must be thoroughly familiar with the automotive field. Ball bearing experience desirable but not required. Practical experience is necessary.

578 Engineer with sales experience and who has a wide acquaintance among engine companies or automobile plants that build their own engines; an acquaintance not only with the purchasing departments but with the engineering departments. Necessary to travel extensively, selling internal-combustion engine valves or other parts that this company makes, such as tappets, etc. Not necessary to make the actual sales because it will be necessary for him to devote himself particularly to the engineering requirements of customers, coming in contact with purchasing departments in an incidental way. Man must be capable of earning good salary and will work under the direction of the chief engineer. Location, Detroit, and traveling will take in entire territory from Minneapolis to New York City.

589 Salesman. Company in Ohio is interested in obtaining a salesman for its industrial bearings division work, covering the sale of its product to industries outside the automotive field where anti-friction bearings are adaptable. This work requires a man with engineering training, as contact is generally with engineers, and sales experience. Prefer a man of about 30 to 35 years of age and single, as the work requires considerable traveling; pleasing personality and plenty of energy are also essential. A man is desired who will appreciate the opportunity of a position with a prominent organization and who will be keenly interested in the work at hand.

590 Implement Designer and Factory Manager. Man able to combine the qualities of both is wanted by plant in Ohio.

*602 Experienced Sales Engineer to cover large territory and call on automobile builders that this company represents. A certain amount of engineering and technical detail is required. Prefer a single man with sales ability and technical knowledge. Salary, from $2,500 to $3,500, according to qualifications, experience and earning power. Write, giving education, experience, salary, etc. Headquarters, Detroit.

*605 Man to take charge of the inspection work of plant, located in New York City and manufacturing piston castings. Enough technical education at least to enable him to understand technical details and enough practical experience in manufacturing lines so as to be familiar in a general way with shop practice are required. Applicants should be familiar with testing machines and equipment, such as Brinell hardness tester, tensile test machine, pyrometer equipment, etc., and be able to use this equipment intelligently; it is also desirable that they understand the operation of gas and oil furnaces; be able to devise and make reports covering work tested as well as to observe work in process through the shop and make such reports as may be required; be competent to take and understand instructions fully, and to follow them out cheerfully. Preferably bright young chap who can stand on his own responsibilities under supervision. Write details fully. Wanted immediately.

607 Automotive Design Engineer. Duties cover original study and engineering work on automotive material, particularly the development of tracklaying and combined wheel and tracklaying mechanisms. Position requires the services of a high-grade man who is able not only to make layout studies on the board, but also to transmit the work to the staff and layout draftsmen for completion of the design. A man of special attainment based upon several years' experience in character of work described is what is desired. Salary, $5,000 for right man; location, Illinois.

(*Continued on p.* 84)

See announcement at the head of the S. A. E. Employment Service column, p. 68.

HOOVER

The World's Largest Ball Plant

STEEL
BRASS
BRONZE
MONEL METAL
BELL METAL
ALUMINUM
AND HOLLOW BALLS

HOOVER STEEL BALL CO.
ANN ARBOR, MICH.

Higher Overload Capacity

BY virtue of their use of the greatest possible number of largest possible size balls, Gurney Bearings withstand shocks and overloads that would be disastrous to other bearings.

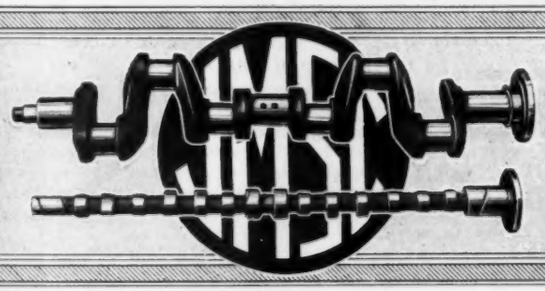
Their remarkable accuracy and uniformity of manufacture—and the fact that their load capacity is greater than other bearings of equal size,—makes Gurneys best suited for replacement work. Their use adds a stronger part to the machine.

If you design machines, our Engineers can help you—will you let them?

Gurney Ball Bearing Co.
Conrad Patent Licensee
Jamestown, N. Y.

GURNEY
BALL BEARINGS

13129



The Largest Manufacturer Finishing Both Crankshafts And Camshafts Exclusively

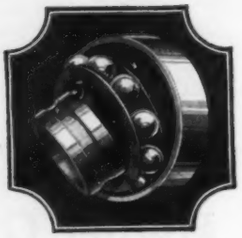
200,000

motors built annually for passenger cars, tractors and trucks are timed by our camshafts and driven by our crankshafts.

Mr. Motor Builder, our experience and facilities merit your consideration.

JACKSON MOTOR SHAFT COMPANY
JACKSON - - - MICHIGAN

"NORMA"
PRECISION
BALL BEARINGS



For Lighting Generators and Ignition Apparatus

The owner of a car or truck—if it fails—notes only the bare fact of failure. Seldom does he seek the ultimate source of trouble. He condemns the machine as a whole—and a subsequent sale is lost.

The builder of a car or truck condemned because of ignition or lighting generator trouble places the blame where it belongs. And the sale, not of one equipment but of hundreds, may be lost to the builder of the electrical apparatus.

Service records prove that magnetos and lighting generators equipped with "NORMA" Precision Bearings, run more quietly, last longer.

A booklet will be sent on request. And our engineers will welcome an opportunity to work with yours.

THE NORMA COMPANY OF AMERICA
Anable Avenue
Long Island City New York
BALL, ROLLER AND THRUST BEARINGS

S. A. E. Employment Service
Continued

POSITIONS AVAILABLE

*611 Production Manager. High-grade factory executive with experience in die-making, foundry, and non-ferrous metals and able to handle men. Location, New York City.

612 Electrical Engineer. A live wire with experience in the repair and maintenance of automotive electrical equipment, who is or could be trained for field service, a man with "pep" who would be able to act on his own initiative is desired. Location, Springfield, Mass.

*613 Steel-Treating Foreman to direct production and maintain equipment. Must be able to handle men and be experienced in present methods. Average output of department six tons per day including carburizing and alloy and carbon steels. Location, California.

616 Salesman is needed by a company about to start a merchandising campaign on a carbureter to take complete charge of the enterprise. Device is fully developed, has had extended commercial service locally and has many advantages. Man should have sound merchandising training: be rather well-known in the industry; technically trained at least in a general way, expert engineering talent is now employed by this company; and have actual experience in selling to the replacement market a product handled through same channels as a carbureter. If he has had this type of experience in the carbureter business, so much the better. Factory equipment solicitation also part of the duties. An interest in the company and compensation in proportion to the results obtained will be offered with a base salary sufficient to preserve a decent standard of living until such results begin to show. Location, Pennsylvania.

622 Engineer; preferably a young man just out of college is wanted immediately for general engineering work, including material testing. Location, suburb of New York City.

*627 Research Man is desired by a prominent company in Connecticut.

*628 Car Tester. Good first-class man is wanted to take charge of rough and finished testing, should be a thorough mechanic and well acquainted with what a high-grade car ought to be, possess a keen mind for analyzing trouble and be a good executive, not white collar man, but one willing to get down to work. Location, Connecticut.

630 General Factory Superintendent for plant whose production is on hose clamps, spark-plugs, automobile pumps, etc., and employs about 60 people, male and female. Equipment consists of automatic screw machines, presses, assembling, etc. Will pay salary with bonus on business to a suitable man possessing a wide experience and capable of producing results.

631 Engine Designers are wanted immediately by an aircraft company in New Jersey for permanent position. Not necessary that applicants have had airplane experience, but preferable. Salary, around $50 per week, or dependent upon the man.

*634 Body Engineer. A permanent position with a reliable organization is open to a high-grade man who is thoroughly familiar with all classes of materials used in body construction, their sources, methods of manufacture and application in body work. He must also be familiar with the production of the bodies themselves and all their component parts, including painting and trimming. Location, Detroit.

*635 Young Sales Engineer with a wide acquaintance among manufacturers. Headquarters, Detroit. Territory, State of Michigan. Salary, commensurate with ability, ranging from $2,500 to $4,000 per year.

*636 Body Engineer with wide experience, who is thoroughly capable and diplomatic and possesses a pleasing personality, to take charge of men in a Connecticut factory.

(*Concluded on p.* 86)

See announcement at the head of the S. A. E. Employment Service column, p. 68.

FRANKLIN DIE-CASTINGS

The Direct Way to RESULTS

We once asked the manufacturer for whom we make this part, "How much did it cost you before you decided to have it die-cast?" He replied, "We never tried to make it any other way."

It could have been built up from a series of stampings mounted on the machine base, but Franklin Die-Castings were a direct way to the results desired, and our customer was wise enough to see it.

This is only one case where the designer, by specifying die-castings, has made a substantial saving possible at the outset.

We originated the Die-Casting Process in 1892, and for 30 years have been reducing costs and simplifying output in many fields of industry.

Let us solve your die-casting problems. We quote from samples or blue-prints. Write for booklet: "Franklin Die-Castings in Modern Inventions."

FRANKLIN DIE-CASTING CORP.
Gifford and Magnolia Streets
Syracuse, N. Y.

To Insure Your Car Upholstery Against Wear, Use

"Wire on" Moulding

A combination of Beauty, Refinement and Stability.

WIRE ON is being successfully used in the trimming of tops and open and closed bodies, both pleasure car and bus.

WIRE ON is made with coverings of genuine leather, artificial leather, and cloth. It is easily and successfully applied on any job.

We have been making Mouldings, Gimps, Welts, Robe Rails, Straps and other Automobile Trimmings for many years.

Samples sent upon request.

The George R. Carter Company

Connersville, Indiana

OWEN Dyneto CORPORATION

Owen-Dyneto Corporation
Syracuse, N. Y.

Manufacturers of High Quality

Starting and Lighting Equipment for the Automotive Industry

Simplicity of Design
All Parts Accessible
Exceptionally Efficient

Service Stations in All Principal Cities and Towns

S. A. E. Employment Service

Concluded

POSITIONS AVAILABLE

637 DRAFTSMEN for automobile work with automobile experience and an acquaintance with S. A. E. Standards are wanted immediately. Preference will be given to men now located in the East. Salary, $30-$45 per week. Location, Massachusetts.

*638 MAN, 30-40 years of age, possessing the ability to write technical articles and lecture, is desired for an executive engineering position. One having had practical automotive engineering experience will be preferred. College education is desirable but not essential. Location, New York City.

639 AUTOMOTIVE ENGINEERS, two or three first-class men, experienced in layout work, tool-designing and transmission, are wanted by company in New Jersey. Salary, $50-$55 per week.

640 SALES ENGINEER on gear cutting and gear tooth-grinding machinery is wanted for Eastern territory with headquarters in New York City. Salary, $200 per month and expenses plus commission. Men in other territories making $5,000 to $8,000 per year on same basis.

641 YOUNG SALES EXECUTIVE to take charge of sales of a growing motor-truck company. Must be capable of compiling sales manuals, formulating sales policies, building up sales organization and supervising advertising. Man of integrity and ability, willing to start with a small salary, is desired. Position offers an opportunity to get in on ground floor with a young organization and build a future. Replies will be held strictly confidential. Location, Ohio.

642 SALES ENGINEER is wanted by a company operating in the States of New York and New Jersey to distribute engineering specialties. Good opportunity for a hustler. Headquarters, New York City.

643 DRAFTSMAN wanted for detail layout work. Salary, around $40 per week. Location, New York City suburb.

644 DESIGNING ENGINEER, who is qualified to design and layout tractor engines and transmissions for quantity production, is wanted by large tractor factory located in California. Only applications from men of broad experience along tractor or other automotive lines will be considered.

645 TECHNICAL GRADUATE, just out of college, is desired immediately to handle testing on aircraft engines. Must be able to conduct tests, write reports and make performance calculations. Airplane experience desirable but not essential. Salary, around $30-$35 per week. Location, New Jersey.

646 CHASSIS LAYOUT DRAFTSMEN Chicago company is in urgent need of several first class men.

647 ENGINE DESIGNERS One or two men with experience are wanted immediately by company in Chicago.

648 PETROLEUM ENGINEER; salary, $3,000-$4,000 per year. Associate petroleum engineer; salary, $2,200-$3,000 per year. Assistant petroleum engineer; salary, $1,800-$2,200 per year. Applications rated as received until further notice. Apply to United States Civil Service Commission, City of Washington, for Form 2118.

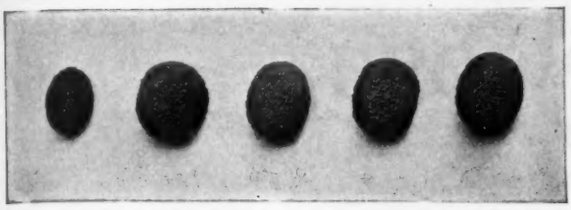
649 LAYOUT DRAFTSMAN Fast worker, preferably with some experience on engine work, is wanted by an airplane company in New Jersey.

*650 ENGINEER, skilled in sheet metal stamping, drawing and die work; must have both technical and practical knowledge and be capable of designing and supervising the design of dies for small and medium size metal stampings, some of which will be of a very complicated character. Location, Michigan.

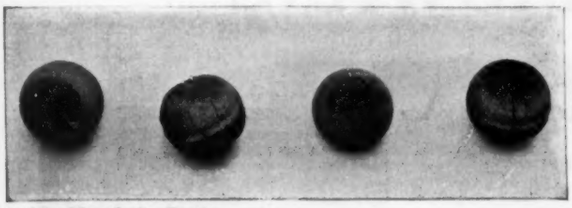
*651 ENGINEER to take charge of research laboratory located at Cleveland and conduct engine tests.

652 DRAFTSMAN-DESIGNERS are wanted immediately for work in New York City. Preference will be given to men from the vicinity of New York City who are experienced in automotive work and general machine design. Salary depends on the man.

See announcement at the head of the S. A. E. Employment Service column, p. 68.



Fafnir Turned Balls deeply etched in hot hydrochloric acid. No sign of cracks.



Cold Headed Balls (not Fafnir) deeply etched in hot hydrochloric acid. Note cracks revealed. All of these balls had been passed by inspectors.

Hot Forged Balls (not Fafnir) deeply etched in hot hydrochloric acid. Note cracks revealed. All of these balls had been passed by inspectors.

The Bearing User Wants UNIFORM Ball Bearings, Not Two or More Poor Ones Out of Every Hundred

Our investigation has shown that in the past the balls have invariably been the weakest part of the bearing. Consequently we have directed our energies to the development of better balls. As the result, we have found turned balls to be far superior to all others.

One has only to glance at the above photographs to see that the profound mechanical deformation which the steel suffers in cold heading or hot forging balls causes severe initial internal strains and stresses which are liable to produce cracks that will cause premature fatigue and failure when the balls are placed in service.

When balls are turned, on the other hand, the normal condition of the steel is perfectly preserved and consequently there is no danger of fatigue.

The "Dragon" for June tells the whole story. Ask us to send you a copy.

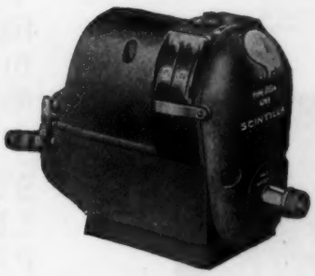
The Fafnir Bearing Company
Conrad Patent Licensee
New Britain, Conn.

CHICAGO, ILL. 537 South Dearborn St.
DETROIT, MICH. 120 Madison Ave., Room 511
CLEVELAND, OHIO. 1016-1017 Swetland Bldg.
NEW YORK, N. Y. 5 Columbus Circle
NEWARK, N. J. 271 Central Ave.
PHILADELPHIA, PA. 1427 Fairmont Ave.

What Is the Cost of Poor Ignition?

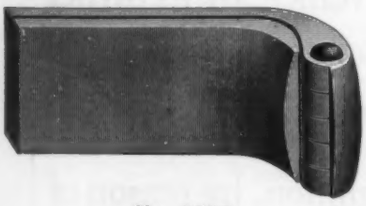
Usually the condemnation of the entire vehicle by its owner because of lost time and annoyance.

Scintilla ignition, by reason of its sound engineering design and splendid construction has proved its unfailing reliability in all classes of service. Witnessed by its universal success in automobile racing, aeronautics and by its choice as standard equipment by the most critical passenger car, truck manufacturers and fleet operators.



SCINTILLA MAGNETO CO., INC.
225 WEST 57th ST., NEW YORK

VEHICLE HARDWARE



No. 9503

Lamp Brackets

Hinges

Hood Fasteners

No. 9507

MALLEABLE IRON CASTINGS

THE EBERHARD MANUFACTURING CO.

CLEVELAND, OHIO

Side View
FLATLITE
All Light Directed Right

Front View

"All the Light—Directed Right"

FLATLITE REFLECTORS

assure perfect road illumination and are approved for use with clear glass lenses, in every state.

There Is No Glare

These scientifically constructed reflectors are figured with highly polished silvered parallel fluted stripes, so controlling the rays of light as to insure safety to driver and approaching car.

STANDARD EQUIPMENT ON CHANDLER, CHEVROLET, OLDSMOBILE, PAIGE, JEWETT and CLEVELAND.

Write Today for Complete Information

THE AMERICAN FLATLITE CO.

4900 Spring Grove Ave., Cincinnati, Ohio

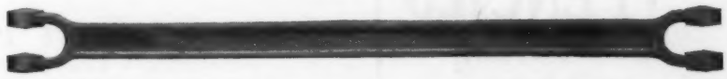
DROP FORGINGS

BACKED BY 40 YEARS' EXPERIENCE

ANYTHING THAT CAN BE DROP FORGED UP TO 300 LBS. ANY ANALYSIS OF STEEL

TYPICAL TRUCK FORGINGS

RADIUS ROD 38 LBS.



MODERN METHODS

TORQUE ARM 37 LBS.

All FACILITIES

UNION SWITCH & SIGNAL CO.

DROP FORGE DIVISION

Pittsburgh District Swissvale, Pa.

Twelve Advantages of Standardization

DESIGNING

(1) Simplifies General Design Work
(2) Proven Engineering Practice Assured

MANUFACTURING

(3) Number of Sizes Reduced to the Desirable Minimum
(4) Production Costs of Many Parts Reduced Because of — Longer Production Runs; Reduced Tool Costs; Overhead Per Piece Reduced
(5) Inventories are Reduced
(6) Sources of Supplies are Increased

MARKETING

(7) Competition is Encouraged
(8) Larger Export Business is Made Possible

OPERATING

(9) Service is Simplified
(10) Less Time "Out-of-Service"

SERVICING

(11) Repair-Parts Stock Reduced
(12) Replacements Facilitated

The World's Most Famous Pencil

VENUS PENCILS

The largest selling Quality pencil in the world

First in the estimation of engineers because of the dependable smoothness, firmness and uniformity of the lead.

17 Black Degrees 3 Copying

For bold, heavy lines . . 6B-5B-4B-3B
For writing, sketching . 2B-B-HB-F-H
For clean, fine lines . 2H-3H-4H-5H-6H
For delicate, thin lines . . . 7H-8H-9H

Plain Ends, per doz. . $1.00
Rubber Ends, per doz. . 1.20

At Stationers and Stores throughout the World

American Lead Pencil Co.
Dept. EN
227 Fifth Ave., New York
also London, Eng.

ESTEEMED

All over the world, wherever motor cars are used, three million drivers of every race and nationality know and trust the Nagel ammeter. Speaking hundreds of languages and representing scores of different civilizations, all use the same sensitive instrument to tell the condition of the generators and the loads the batteries are carrying.

NAGEL AMMETER
THE W.G.NAGEL ELECTRIC CO.
TOLEDO OHIO

MEMBERS' PROFESSIONAL CARDS

FRANCIS W. DAVIS
CONSULTING ENGINEER
DESIGN—DEVELOPMENT—TESTS—OPERATION—MOTOR CARS—TRUCKS—AUXILIARY EQUIPMENT
COMPLETE EXPERIMENTAL DEPARTMENT
METZ BUILDING WALTHAM, MASS.

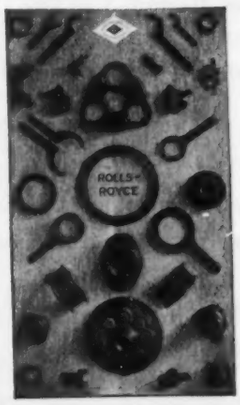
Consulting Engineer **Ethelbert Favary** Author of Books on Motor Vehicle Design
AUTOMOTIVE TRANSPORTATION PROBLEMS
REPORTS DEVELOPMENT DESIGN RESEARCH
Engines and Chassis Redesigned for Quantity Production.
Machines and Devices designed, constructed and tested.
Complete Drafting and Machine Shop Service
17 W. 42nd St., New York Longacre 10134

Chas. M. Manly, A. S. M. E. S. A. E. — C. B. Veal, A. S. M. E. S. A. E.
Manly and Veal
(Consulting Engineers)
mechanical—automotive—industrial
Coordination of engineering and manufacturing requirements in the design, production and operation of automotive power plants and vehicles.
Design, Development, Specifications, Organization, Inspection, Investigation, Tests and Reports
250 West 54th Street, New York City.

S. A. E., *New York* A. S. M. E., *New York* I. A. E., *London*
Cornelius T. Myers, M. E.
CONSULTING ENGINEER
REPORTS—DESIGN—TESTS—DEVELOPMENT
Cooperation on Purchase and Upkeep of Trucks, Buses and Rail Cars.
RAHWAY NATIONAL BANK BLDG. RAHWAY, N. J

E. PLANCHE, A.M., S.A.E., A.S.M.E.
Consulting Engineer, Automotive Designer and Builder
Development Work on Motors, Chassis, Bodies and Accessories.
Special Designs for Economical Operation of Motor Cars.
Special Designs for Economical Building of Automobile Bodies.
GENERAL MOTORS BUILDING, ROOM 5-110, DETROIT, MICH.

S. A. E. A. H. T. A. A. S. M. E. — N. G. E. A. N. A. F. E. M.
O. E. Szekely Co.
MOLINE, ILLINOIS
Mechanical and Automotive Engineers.
Engineering and Laboratory Departments. Complete Experimental Equipment. Testing Machines. Universal Machine Shop and Pattern Shop for Single Piece Reproduction of Our Designs.



Williams' Superior Drop-Forgings

Are forgings of quality, made by "The Drop-Forging People" with nearly half a century's experience behind them.

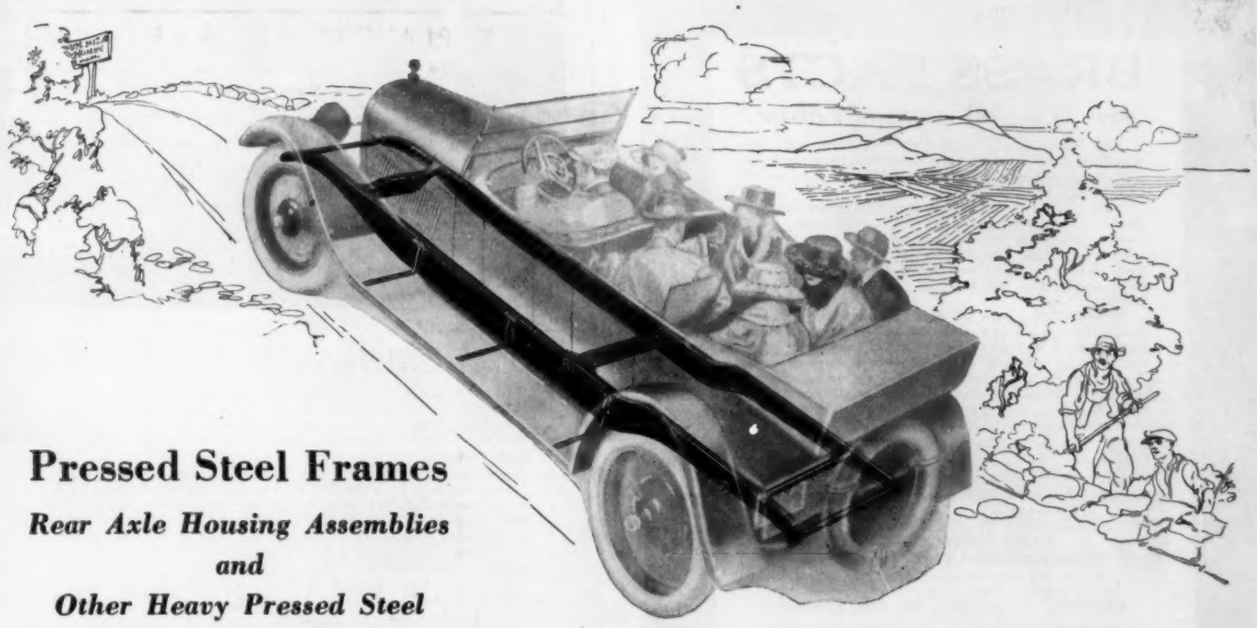
J. H. WILLIAMS & CO.
"The Drop-Forging People"
BROOKLYN BUFFALO CHICAGO

NATIONAL
RADIATORS

Here is probably America's most famous radiator—the National. Both the Zig-Zag Circular and Spiral Tube Nationals are found on some of the best known passenger cars, trucks and tractors. This is significant and should be very indicative to you. Quality cars require quality units. When it comes to the radiator—select the National.

NATIONAL CAN CORPORATION

Radiator Division Detroit, Michigan



Pressed Steel Frames

Rear Axle Housing Assemblies
and
Other Heavy Pressed Steel
Parts for the Automobile

A. O. SMITH CORPORATION

Milwaukee, Wisconsin *Detroit: 708 Ford Bldg.*

Sterling is the largest producer of Dash Ammeters in the world!

Sterling Dash Ammeters are made according to S. A. E. standards.

Sterling

Model 500

DASH AMMETERS

Standard Equipment on many of America's leading cars. Their simple and rugged construction adapts them for long and satisfactory service.

Volume production, long experience, modern daylight plant of fireproof construction, up-to-the-minute special machinery, economical, efficient management, low "overhead" expense, a beautiful thoroughly reliable, time-tested product; these are the advantages which we share with those car manufacturers who make STERLING ammeters standard equipment.

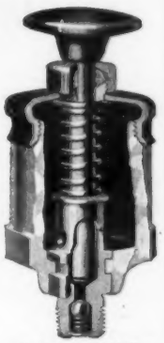
Flush or projecting cases in any style or finish. Etched metal dials finished in black or silver, any scale.

Write for descriptive matter, samples or quotations.

THE STERLING MFG. CO.

2831-53 Prospect Ave., Cleveland, Ohio
Detroit Office, 1309 Kresge Bldg.

How Oil-Kipps Work



Vertical Oil-Kipp

Every Oil-Kipp is a complete pumping unit contained in a heavy die-cast aluminum cup carrying several months' supply of heavy oil.

They are operated by merely pumping the spring pistons.

Their success in forcing heavy oil around tight fitting bearings is due to a simple hydraulic principle.

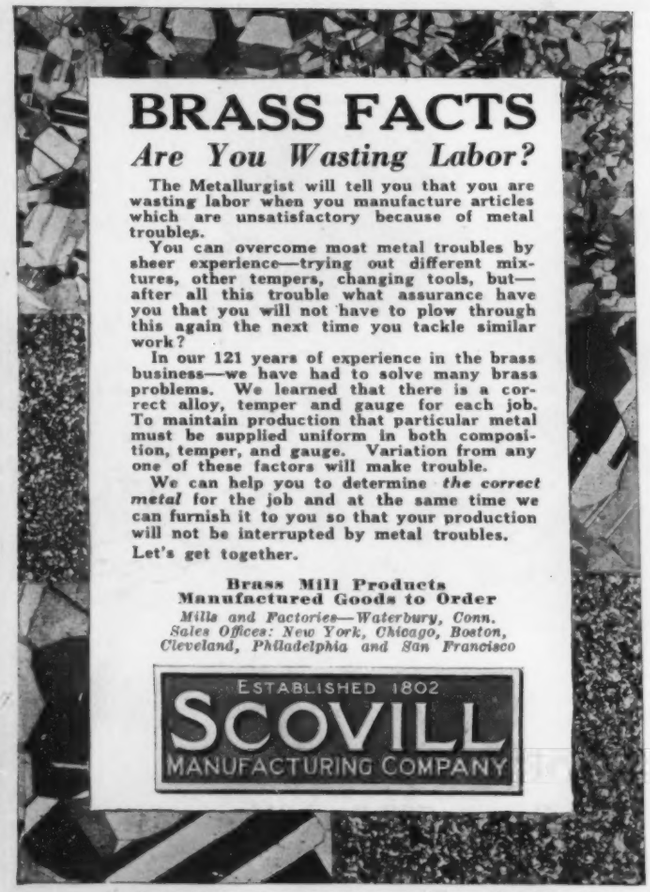
The outstroke of the plunger creates a vacuum in the barrel, so that oil is sucked into it from the cup.

The instroke of the plunger puts this oil under pressure, because the plunger is so small in diameter that each pound of pressure exerted on the handle means a great many pounds in the pump.

In varying locations they are used as standard equipment on Nash, Stearns, and Oakland cars. There are two types, vertical and horizontal.

Madison-Kipp Corporation, Madison, Wisconsin

Oil-Kipps



BRASS FACTS

Are You Wasting Labor?

The Metallurgist will tell you that you are wasting labor when you manufacture articles which are unsatisfactory because of metal troubles.

You can overcome most metal troubles by sheer experience—trying out different mixtures, other tempers, changing tools, but—after all this trouble what assurance have you that you will not have to plow through this again the next time you tackle similar work?

In our 121 years of experience in the brass business—we have had to solve many brass problems. We learned that there is a correct alloy, temper and gauge for each job. To maintain production that particular metal must be supplied uniform in both composition, temper, and gauge. Variation from any one of these factors will make trouble.

We can help you to determine *the correct metal* for the job and at the same time we can furnish it to you so that your production will not be interrupted by metal troubles.

Let's get together.

Brass Mill Products
Manufactured Goods to Order

Mills and Factories—Waterbury, Conn.
Sales Offices: New York, Chicago, Boston, Cleveland, Philadelphia and San Francisco

ESTABLISHED 1802
SCOVILL
MANUFACTURING COMPANY

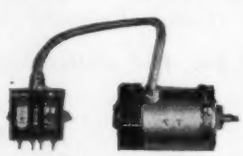
Border illustrates the microstructure of Brass Mag. 75x

The BUSINESS POWER *of* LIGHT

LIKE the far-famed illumination of the Great White Way of New York, brightly lighted motor busses advertise your service and attract patrons. There is no longer any question about the power of light to pull business. Night service by busses can be made as profitable as daylight operation.

Leece-Neville equipment was designed to improve and perfect motor bus operation. It is the first lighting and starting equipment in the field with ample capacity to take care of the heavy duty requirements of motor busses. Its reliability, efficiency and economy are recognized by every user. Leece-Neville Generators and Compensators are the *only equipment* which automatically cares for the difference in current required between day and night operation. Send for full details.

Leece-Neville Electrical Equipment is furnished on the product of
Autocar Company
Brockway Motor Truck Co.
Mack International Motor Truck Corp.
The White Motor Co.
The Haynes Automobile Co.
and a number of others.



THE LEECE-NEVILLE CO.
Cleveland, O.

LEECE-NEVILLE

12 Volt Lighting Systems *for* Motor Busses

Millions of Gallons of TEXACO lubricants are used today

MILLIONS of gallons of TEXACO LUBRICANTS are used today in power plants, factories, mills, on railroads, in steamships, and in mines.

Back of our widespread production resources, mammoth Texaco refineries and capable delivery service are working night and day to supply the oil needs of a steadily increasing number of new customers in all parts of the world.

TEXACO doesn't often lose a customer

The suitability of Texaco Lubricants, their quality, their uniformity,—in barrel after barrel, month after month,—these things cannot fail to commend them to all interested in securing the right oil for the right place.

The success of Texaco Lubricants is bound up with Texaco Lubrication Engineering Service. This consists of giving our customers the benefit of the experience of our staff of highly trained lubrication specialists. As a matter of fact, even before we take your order we shall be glad to have a Texaco Lubrication Engineer make a survey of your plant; after which he will indicate the right kind and the right amount of lubricant for every type of unit or machine—in every department.

TEXACO LUBRICANTS are stocked in over 600 Texaco Warehouses in all parts of the country; and are ready for shipment in any quantity,—tank car, barrel or can; by water, rail or truck with Texaco promptness.

If there should be no warehouse or Texaco Station in your city, write us here, or address our nearest district office, and your oil requirements will be promptly and fully cared for.

The Texas Company
17 Battery Place, New York City
New York Chicago Houston
Offices in Principal Cities

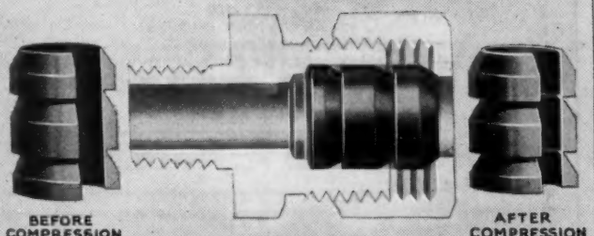
The Universal Push Button

PERFECT CONTACT IS SECURED ON ANY ANGLE

More Than Two Million in Use

The General Phonograph Mfg. Co.
(Formerly named The Garford Mfg. Co.)
ELYRIA, OHIO

DOHNER COMPRESSION COUPLINGS

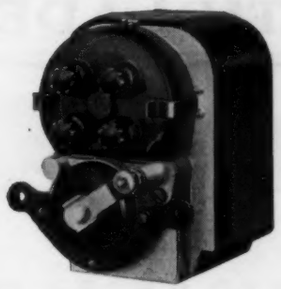


for COPPER, BRASS *or* STEEL TUBES *for* GAS, GASOLENE OIL, WATER, STEAM *or* AIR

Approved by Underwriters Laboratories

ASK US FOR DATA SHEETS

The
OHIO METAL PRODUCTS CO.
Dept. "A" Dayton, Ohio.
Sales Office, Free Press Bldg., Detroit, Mich.



SIMPLICITY-RUGGEDNESS
EFFICIENCY-RELIABILITY
Always associate these Qualities with

TEAGLE MAGNETO

A BETTER SPARK IN A SIMPLER WAY

Conforms to S. A. E. Standards
THE TEAGLE CO., Cleveland, O.
You want to know more about this *simplest* magneto—write 1128 Oregon Avenue for details.

Three of a Kind

A COMBINATION HARD TO BEAT

S.A.E. = A **Society** worth while

"Van Dorn" GEARING = **Gears** of Quality Differentials Bevels and Spiral Bevels Transmission Gear Sets

AGMA = An **Association** that raises the standard of all

THE VAN DORN & DUTTON CO.
Gear Specialists
CLEVELAND, OHIO

Good Equipment Builds Good Will

Adopt

ARROW GRIP JACKS

Handle Controlled

as standard equipment and insure satisfaction-service.

Built for dependability and convenience.

Worm and nut type of lifting mechanism.

Operated from a standing position—a few easy turns of the long extension handle raises or lowers the car. Hands and clothes are kept clean.

Broad, topple proof base gives firm foundation on any kind of ground.

Two sizes fit all cars and trucks. Pack in small space.

Correspondence Invited

Arrow Grip Mfg. Co., Inc.
100-120 Cooper St.
Glens Falls, N. Y.

Export Office: 280 Broadway, New York

MULTIBLADE FAN

DETROIT CARRIER & MFG. CO.
DETROIT, U. S. A.

THE WM. D. GIBSON COMPANY

1800 CLYBOURN AVENUE
CHICAGO, ILL.

MANUFACTURERS OF HIGH GRADE
SPRINGS
OF EVERY DESCRIPTION

SPRING FORMULAS

NOTATION
W = LOAD IN POUNDS
D = MEAN DIA. COIL (INCHES)
d = DIA. WIRE (ROUND) "
N = NUMBER OF COILS (ACTIVE)
G = TORSION MODULUS (11 500,000)
f = DEFLECTION (IN INCHES)
S = TORSIONAL STRESS

$$W = \frac{3.14\,S\,d^3}{8D}$$

$$W = \frac{f\,G\,d^4}{8\,N\,D^3}$$

In a spring with ends squared and ground N is the total number of coils minus 2.

Maximum stresses permissible vary with conditions—from a safe maximum of 40,000 for high speed engine valve work to as high as 110,000 for static loads and ordinary temperatures.

Co-operation with your engineers in specific cases is one of our lines of service.

WE MAKE SPRINGS FOR ANY PURPOSE IN ANY MATERIAL

CARBON STEELS — ALLOY STEELS — PHOSPHOR BRONZE — BRASS — MUSIC WIRE — SPECIAL MATERIALS

COMPRESSION EXTENSION FLAT TORSION SPECIAL SHAPES

We have the above on celluloid cards. WRITE FOR ONE.

STANDARD STEEL SPRING COMPANY

CORAOPOLIS, PA.

MANUFACTURERS of LEAF SPRINGS

Builders to the most discriminating passenger car and truck manufacturers in the United States and Europe.

UNION DRAWN STEEL COMPANY

ESTABLISHED 1889
Cable Address—"UNIONDRAWN, NEW YORK"

BRIGHT FINISHED STEEL

Manufacturers of

Cold Drawn and Turned and Polished Shafting and Free Cutting Screw Steels
and
Cold Drawn Steel Squares, Flats and Hexagons
Cold Drawn Special Shapes
Cold Drawn or Turned and Polished Pump and Piston Rods
Cold Drawn Elevator Guides
Cold Drawn or Turned and Polished Axles

Cold Drawn or Turned and Polished One Per Cent. and Three and One-Half Per Cent. Nickel Steels and Chromium Steels
Vanadium Steels
Nickel-Chromium Steels
Chrome-Vanadium Steels
Bright Bessemer, Open Hearth, Alloy and Electric Steels

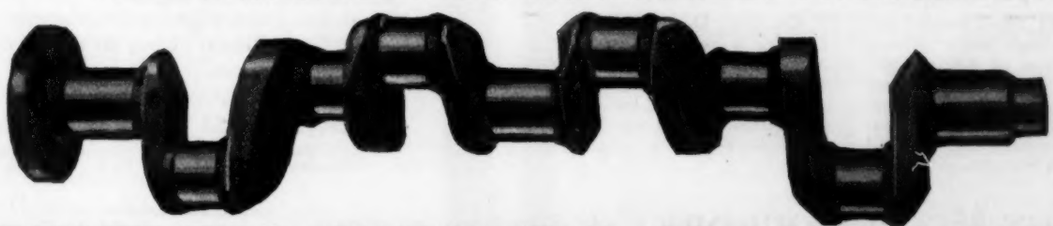
For Special Work in a Wide Range of Analyses

Complete Laboratory and Heat Treating Plant

UNION DRAWN STEEL COMPANY, *General Offices and Works*, Beaver Falls, Pa., and Gary, Ind.

BRANCH OFFICES: *Boston, Buffalo and Cleveland.* BRANCH OFFICES AND WAREHOUSES: *Chicago, Cincinnati, Detroit, New York and Philadelphia*
Pacific Coast Representatives—The Milton Pray Co., Monadnock Bldg., San Francisco and Washington Bldg., Los Angeles, Calif. and L. C. Smith Bldg., Seattle, Wash.
Foreign Representative—W. E. Knight, 2 and 3 Norfolk St., Strand, London, England, W. C. 2.

METALLURGICALLY AND MECHANICALLY SUPERIOR



"TWISTLESS FORGED" CRANK SHAFTS

MADE BY

CANTON DROP FORGING & MFG. COMPANY, CANTON, OHIO

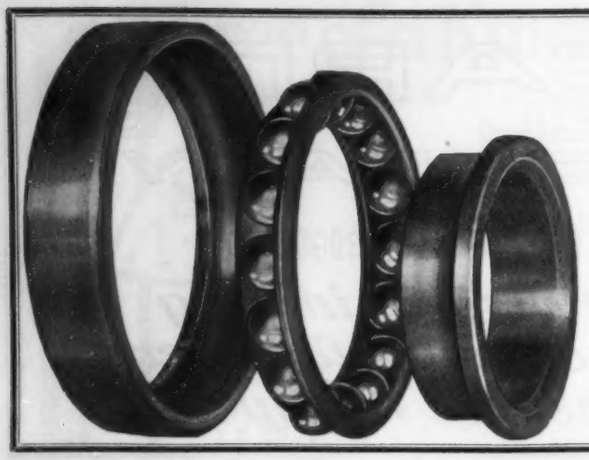
"PRODUCTS THAT STAND THE TEST"

Manufacturers of—
GASOLINE GAUGES
OIL LEVEL GAUGES
WELDED STEEL RINGS AND BANDS FOR FLYWHEEL GEARS SPROCKETS, ETC.
6" to 60" in Diameter

THE AKRON-SELLE CO.

AKRON, OHIO

35 Years in Business



THE BEARINGS COMPANY OF AMERICA

◆ ◆ ◆

Angular Contact Radial Bearings and Angular Contact Thrust Bearings.

Manufacturers of Thrust Ball Bearings for all sizes and types of machines

Standard sizes of Thrust Ball Bearings and Special Thrust Ball Bearings

Your inquiries solicited

Detroit Office:
1012 Ford Bldg.

Factory:
Lancaster, Penna.

Motor and Transmission Department

Let us know fully what you expect from us both in quality of work and in time of delivery.

Our equipment and organization is such as to qualify us for meeting your every need and in many cases doing what might seem impossible to anyone not familiar with our resources.

Write for the L. M. F. Book.

Foundry Department

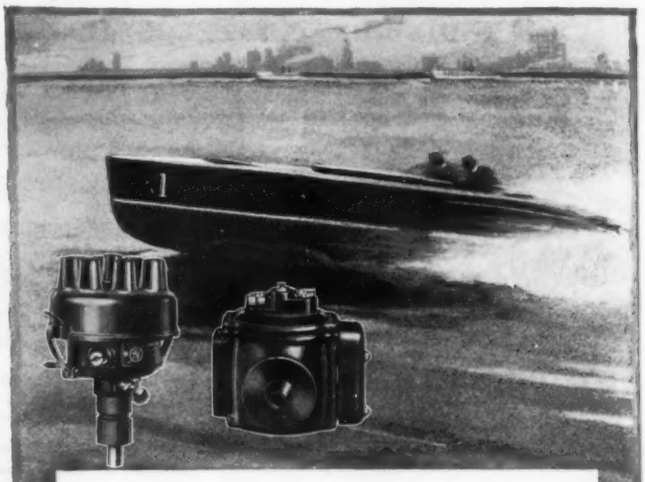
More than once our quotations have proved our claim of being specialists in saving expense in the casting of Aluminum, Manganese, Phosphor Bronze, Bearing and all Non-Ferrous metals.

Quality Die Castings

Quality Die Castings present a real saving in costs for jigs, tools and fixtures and our exclusive process enables us to assure deliveries in less time than you might expect.

LIGHT MFG. & FOUNDRY CO.

POTTSTOWN, PA., U. S. A.



The Sterling Marine Engine Co. have adopted North East Battery Ignition because they needed absolute reliability. Used on their 4, 6, and 8 Cylinder Engines.

NORTH EAST ELECTRIC CO.

ROCHESTER N.Y. U.S.A.

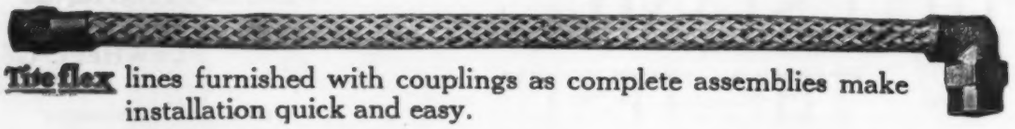
Manufacturers of

Starter-Generators Starting Motors
Generators Ignition-Generators
Ignition Sets Speedometers Electric Horns

Titeflex Oil, Water and Gasoline Lines for Automobiles, Trucks and Tractors.

250,000

TITEFLEX LINES INSTALLED IN THIS SERVICE.



Titeflex lines furnished with couplings as complete assemblies make installation quick and easy.

TITEFLEX METAL HOSE CORPORATION

BADGER AVE. and RUNYON ST. NEWARK, N. J.

NOTICE

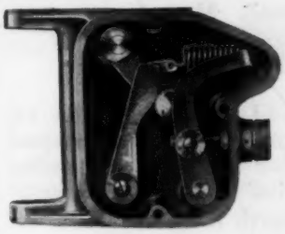
Effective July 1st, 1921, a 5% discount from Collision premiums on Commercial automobiles is permissible for the attachment of an approved front bumper and/or an approved radiator guard. (5% shall be the maximum reduction, even when both bumper and guard are attached.) This reduction shall apply to full coverage, $50 deductible, and $100 deductible.

This reduction in premium should make it worth your while to investigate the merits of the Mansfield Front Bumper, Standard and Packard Special Radiator Guards, all of which have been "Listed as Standard" by the Underwriters' Laboratories.

MANSFIELD STEEL CORPORATION
954 East Milwaukee Avenue Detroit, Michigan

G & O Radiators

THE G & O MANUFACTURING CO.
Tubular and Honeycomb Radiators
NEW HAVEN CONN.



Sectional View showing simple construction

The Handy Governor

Thousands in use on trucks and tractors giving splendid satisfaction.

Made in standard sizes for motors ranging from 100 to 650 cu. in.

Our engineering department will be glad to discuss your governor problem. Literature on request.

Handy Governor Corporation
3021 Wabash Ave. Detroit, Mich.

FULLER-LEHIGH

Pulverized Coal Equipment is economically preparing and burning over 40,000 tons of various grades of coal per day for Boilers and Industrial Furnaces.

EQUIPMENT INCLUDES

Pulverized Mills, Air Separator and Screen Type; Crushers; Dryers; Feeders; Burners—Horizontal and Vertical Types; Fuller-Kinyon Conveying Systems.

Let us give you more detailed information.

FULLER-LEHIGH CO.
Fullerton, Pa.

SHULER FRONT AXLES
for
MOTOR BUSES, TRACTORS
MOTOR TRUCKS and
TRAILERS

The Shuler Axle Company makes front axles *exclusively*. Concentration of all our experience and energy on this one vitally important major unit should and is producing a superior front axle.

Our engineers will co-operate to develop the most efficient Shuler Front Axle for you.

Write for any further information desired.

SHULER AXLE COMPANY, Incorporated
3011 JONES STREET LOUISVILLE, KENTUCKY, U. S. A.

Johns-Manville Aids Buyers of Automotive Equipment

Automotive Engineers, in the market for automotive equipment, will find Johns-Manville Engineers ready to offer co-operative service on Johns-Manville automotive equipment, at any of our branches. Johns-Manville serves all industry, the automotive being one of many in which we have specialized.

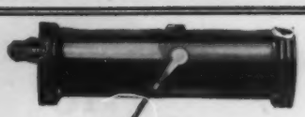
Write, wire or phone our nearest branch.

JOHNS-MANVILLE
Automotive Equipment

- Non-Burn Asbestos Brake Band Lining
- Johns-Manville Asbestos Brake Lining for Ford Cars
- Johns-Manville Asbestos Clutch Rings and Facings
- Johns-Manville Speedometers
- Johns-Manville Hub Odometer
- Johns-Manville Auto Tape
- Johns-Manville Automotive Packings

JOHNS-MANVILLE SERVICE COVERS THE CONTINENT

JOHNS-MANVILLE, Inc.
New York City Branches in 56 Large Cities



Manufacturers Model

This model especially built for car manufacturers is rapidly being adapted as standard equipment by leading makers. Full information on request.

The Folberth Auto Specialty Co.

Cleveland Ohio

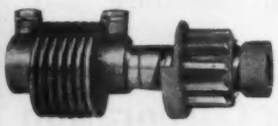
FOLBERTH *Automatic* **WINDSHIELD CLEANER**

Bolts—Nuts Rivets Washers and Forgings for Automotive Construction

The Columbus Bolt Works Co.

COLUMBUS, OHIO

The **BENDIX DRIVE** *for* ELECTRIC STARTERS



AUTOMATIC ENGAGING & DISENGAGING

Standard Equipment on the Electric Starters of a Large Majority of the World's Motor Cars and Trucks.

ECLIPSE MACHINE CO.

ELMIRA - N.Y. -

Walkerville, Ontario

FIBREBOARD AND CARDBOARD PARTS FOR AUTOMOBILE BODIES

We Supply Accurately Die Cut

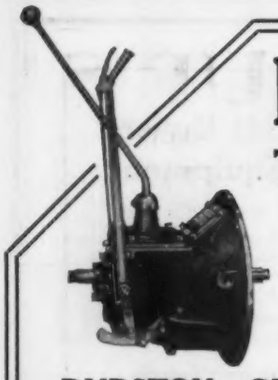
PANELS

BREAKOVERS

GASKETS

Cardboard Cutting & Supply Co.

1571 WELLINGTON AVE. DETROIT



DURSTON TRANSMISSIONS

For passenger cars and trucks up to one-ton capacity. Investigate their adaptability to your requirements.

DURSTON GEAR CORPORATION

134 Maltbie St., Syracuse, N. Y.

AUTOMOBILE LAMPS

We are completely equipped to produce motor vehicle lamps, whether of electric, gas or oil construction, in any quantity desired. We solicit the privilege of submitting samples and quoting prices.

The Jno. W. Brown Mfg. Company

Columbus Ohio

SHEET METAL STAMPING

We are building axle housings, brake drums, and other parts for the heaviest motor trucks ever built, and have ample capacity for still heavier.

With our complete equipment we cover the entire sheet metal stamping line.

We solicit your inquiries.

THE CROSBY COMPANY.

DETROIT OFFICE: 914 Ford Bldg. BUFFALO, N. Y. CLEVELAND OFFICE: 415 Schofield Bldg.

PHILADELPHIA OFFICE

New York Office: 30 Church Street

Biflex *Spring Bumper*

Blocks other bumpers of all heights. "Full-looped" ends provide recoil which absorbs terrific crashes. Biflex Brackets can't come loose or rattle.

There's only One Biflex—the Original.

TRADE MARK

BIFLEX PRODUCTS CO.

Waukegan, Ill.

"Protection with Distinction"

HARDNESS MEASUREMENTS

Made With **The SCLEROSCOPE**

Are comparatively rapid and inexpensive.
Do not mar finished surfaces.
Do not strain and start fractures in metal.
The only instrument that can be applied to dead soft metals and intensely hard steel.
The only instrument that measures material from extreme thinness to unlimited size.
Cheapest to install, cheapest to maintain.
Recognized as international standard.
Send for free literature.

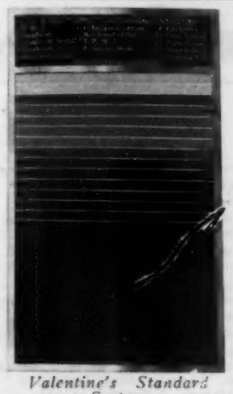
THE SHORE INSTRUMENT & MFG. CO.
Van Wyck Avenue and Carll Street
Jamaica, New York

TRADE **VALENTINES** MARK

No system of Automobile finishing can give proper results unless each material of the system bears the proper relationship to all the others.

Three properly "engineered" systems are described in our Booklet on Automobile Painting. It is yours for the asking.

VALENTINE & COMPANY
Established 1832
New York Chicago Boston



Valentine's Standard System

LAMINUM

Laminated Shims are made of thin layers of brass, which are peeled off to secure the thickness required for accurate bearing adjustments. Furnished babbitt-faced or plain. In standard patterns or to order.

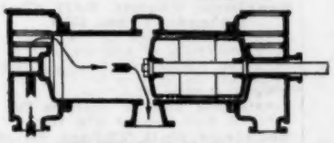
LAMINATED SHIM CO., Inc.
14th St. and Governor Pl.,
Long Island City, N. Y.
Detroit: Dime Bank Building
St. Louis: Mazura Mfg. Co.

This Book Containing Exact Information on the Latest Developments in Steam Engine Practice.
Should be in the hands of Every Engineer.

$4.00
Post paid

The Una-Flow Steam Engine
By J. Stumpf

STUMPFLOW



DESIGN

Stumpf Una-Flow Engine Co., Inc.
206 E. Genesee St.
Syracuse, N. Y.

The Heat Is There— Why Not Use It?

PERFECTION MOTOR CAR HEATERS

The Perfection Heater & Mfg. Co.
6545 Carnegie Ave., Cleveland, Ohio

MOLTRUP'S

Accurately Finished Free Cutting Cold Drawn

SCREW STEEL

is specified by particular manufacturers of high grade automotive parts.

ROUNDS—HEXAGONS—SQUARES—FLATS
COLD DRAWN SHAFTING AND SPECIAL SHAPES

Other Moltrup Products:
Finished Machine Keys, Standard Woodruff Keys, Finished Machine Rack, Flattened, Ground and Polished Steel Plates and Discs, Foundry Pattern Plates, Finished Crank Shafts

MOLTRUP STEEL PRODUCTS CO., Beaver Falls, Pa.

MARKO
STORAGE BATTERIES

For Automobiles and Radio
Quality Built
Price Right
Service Guaranteed

Built to S. A. E. Standards

ALWAYS DEPENDABLE

MARKO STORAGE BATTERY CO.
1402 Atlantic Avenue, Brooklyn, N. Y.

Counter Balanced Crank Shafts

MADE BY

THE PARK DROP FORGE CO.
CLEVELAND, OHIO

INDEX TO ADVERTISERS' PRODUCTS

Marketed as Conforming With S.A.E. Standards and Recommended Practices, and Products for Which There Are No S.A.E. Standards

Absorbers, Shock
Watson Co., John Warren

Alloys, Alumino-Vanadium
Vanadium Corporation of America

Alloys, Cupro-Vanadium
Vanadium Corporation of America

Alloys, Ferro-Molybdenum
Vanadium Corporation of America

Alloys, Ferro-Tungsten
Vanadium Corporation of America

Alloys, Ferro-Vanadium
Vanadium Corporation of America

Alloys, Steel (See Steels)

Aluminum Alloys, D104
*Hoyt Metal Co.

Ammeters, B12
*Nagel Electric Co., W. G.
*Sterling Mfg. Co.
Westinghouse Electric & Mfg. Co.

Apparatus, Charging, Electric Vehicle
Westinghouse Electric & Mfg. Co.

Apparatus, Laboratory
Olsen Testing Machine Co., Tinius

Axles, Front, Motor-Truck, F1b
*Eaton Axle Co.
Sheldon Axle & Spring Co.
Timken-Detroit Axle Co.

Axles, Front, Passenger-Car
Eaton Axle Co.
Salisbury Axle Co.
Timken-Detroit Axle Co.

Axles, Rear, Motor-Truck
Eaton Axle Co.
Sheldon Axle & Spring Co.
Timken-Detroit Axle Co.

Axles, Rear, Passenger-Car
Eaton Axle Co.
Salisbury Axle Co.
Timken-Detroit Axle Co.

Axles, Trailer
Salisbury Axle Co
Timken-Detroit Axle Co.

Babbitt, D103
*Franklin Die-Casting Corporation
*Hoyt Metal Co.
*Light Mfg. & Foundry Co.
*Mussy-Lyon Co.

Balls, Brass, Bronze, Monel Metal, Aluminum
Atlas Ball Co.
Hoover Steel Ball Co.

Balls, Hollow Bronze and Brass
Hoover Steel Ball Co.

Balls, Steel
Hoover Steel Ball Co.

Bars, Boring
Williams & Co., J. H.

Bars, Bronze
Bunting Brass & Bronze Co.
Mueller Metals Co.

Batteries, Storage, B23
*Marko Storage Battery Co.
*Westinghouse Union Battery Co.
*Willard Storage Battery Co.

Bearings, Babbitt and Aluminum
Bunting Brass & Bronze Co.
Doehler Die-Casting Co.
Franklin Die-Casting Corporation

Bearings, Babbitt and Bronze
Bunting Brass & Bronze Co.
Doehler Die-Casting Co.
Hoyt Metal Co.
Mueller Metals Co.
Mussy-Lyon Co.

Bearings, Ball, Angular Contact Type, C33 to C33e
*Bearings Co. of America
*Fafnir Bearing Co.
*Gurney Ball Bearing Co.
*New Departure Mfg. Co.
*U. S. Ball Bearing Mfg. Co.
*S K F Industries, Inc.

Bearings, Ball, Annular, Extra Small Series, C33
*Fafnir Bearing Co.
*New Departure Mfg. Co.
*S K F Industries, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Annular, Extra Large, Light and Medium Series, C27 and C29
*Fafnir Bearing Co.
*Gurney Ball Bearing Co.
*S K F Industries, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Annular, Light, Medium and Heavy Series, C26, C28 and C30
*Fafnir Bearing Co.
*Federal Bearings Co., Inc.
*Gurney Ball Bearing Co.
*New Departure Mfg. Co.
*Norma Co. of America
*S K F Industries, Inc.
*Standard Steel & Bearings, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Annular, Separable (Open) Type, C32
*Fafnir Bearing Co.
*New Departure Mfg. Co.
*Norma Co. of America

Bearings, Ball, Annular, Wide Type, C31
*Brown-Lipe Gear Co.
*Fafnir Bearing Co.
*New Departure Mfg. Co.
*S K F Industries, Inc.
*Standard Steel & Bearings, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Bronze
Hoyt Metal Co.
Mueller Metal Co.
Mussy-Lyon Co.

Bearings, Thrust, Ball, Clutch Release Type, C39
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma Co. of America
*S K F Industries, Inc.
*Standard Steel & Bearings Co.
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Single-Direction, Flat-Face Type, C35 and C36
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma Co. of America
*S K F Industries, Inc.
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Single-Direction, Self-Aligning Type, C37 and C38
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma Co. of America
*U. S. Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Steering Knuckle Type, C34
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma Co. of America
*U. S. Ball Bearing Mfg. Co.

Bearings, Roller, Inch-Type
Hyatt Roller Bearing Co.
Timken Roller Bearing Co.

Bearings, Roller, Metric-Type, C43 and C44
*Rock Bearing Co.
Rower Roller Bearing Co.
Gilliam Mfg. Co.
Hyatt Roller Bearing Co.
*Norma Co. of America
*S K F Industries, Inc.
*Shafer Bearing Corporation

Bindings
Carter Co., George R.

Blanks, Gear
Akron-Selle Co.
Canton Drop Forging & Mfg. Co.
Central Steel Co.
Link-Belt Co.
Park Drop Forge Co.
Standard Gauge Steel Co.
Union Switch & Signal Co.

Blanks, Sprocket
Akron-Selle Co.

Blocks, Fuse and Junction
Briggs & Stratton Co.

Boards, Floor and Toe
Parish Mfg. Corporation

Bodies, Passenger Car
Baker R & L Co.

Bodies, Motor Truck Dump
Mansfield Steel Corporation

Boilers, Steam, Automotive
Stumpf Una-Flow Engine Co., Inc.

Bolts, Carriage
Columbus Bolt Works Co.

Bolts, Connecting-Rod, A5
*Ferry Cap & Set Screw Co.

Bolts, Eye
Williams & Co., J. H.

Bolts, Fender
Columbus Bolt Works Co.

Bolts, King
Ferry Cap & Set Screw Co.

Bolts, Spring Shackle
Bowen Products Corporation
Ferry Cap & Set Screw Co.

Bolts, Step
Columbus Bolt Works Co.

Bolts, Tie-Rod
Ferry Cap & Set Screw Co.

Brackets, Fender
Parish Mfg. Corporation
Smith Corporation, A. O.

Brackets, Running-Board, H23
Crosby Co.
Parish Mfg. Corporation
Smith Corporation, A. O.

Brake-Drums
Crosby Co.
Parish Mfg. Corporation
Smith Corporation, A. O.

Brass, Laminated
Laminated Shim Co., Inc.

Breakers, Circuit
Dayton Engineering Laboratories Co.

Bronze Alloys, D108
*Hoyt Metal Co.

Buckram
Carter Co., George R.

Bulbs, Incandescent Lamp, B3
Westinghouse Electric & Mfg. Co.

Bumpers, Motor Truck
Mansfield Steel Corporation

Bumpers, Spring
Thermoid Rubber Co.

Bumpers, Passenger Car, C55, and H24
Bijlex Products Co.
*Stewart-Warner Speedometer Corporation

Burners
Fuller-Lehigh Co.

Bushings, Babbitt
Mussy-Lyon Co.

Bushings, Bronze
Bunting Brass & Bronze Co.
Detlaff Co., A. J.
Hoyt Metal Co.
Mueller Metals Co.
Mussy-Lyon Co.

Buttons, Electric Push
General Phonograph Mfg. Co.

Cable, Insulated, B33
Kerite Insulated Wire & Cable Co.
*Packard Electric Co.

Cabs, Motor Truck
Highland Body Mfg. Co.

Camshafts
Canton Drop Forging & Mfg. Co.
Jackson Motor Shaft Co.
Park Drop Forge Co.
Wyman-Gordon Co.

Caps, Hub
Crosby Co.

Caps, Radiator and Tank, C58a
*Stewart-Warner Speedometer Corporation

Carburetors, Cast Iron, A8
*Byrne, Kingston & Co.
Zenith Carburetor Co.

Carburetors, Motorcycle
Zenith Carburetor Co.

Carburetors, A8
*Byrne, Kingston & Co.
*Stewart-Warner Speedometer Corporation
Zenith-Detroit Corporation.

Cast Brass Alloys, D106
*Hoyt Metal Co.

Castings, Aluminum**
*Doehler Die-Casting Co.
*Franklin Die-Casting Corporation
Hoyt Metal Co.
*Light Mfg. & Foundry Co.
Scovill Mfg. Co.

Castings, Brass**
*Doehler Die-Casting Co.
*Franklin Die-Casting Corporation
*Light Mfg. & Foundry Co.
Mueller Metals Co.
*Scovill Mfg. Co

Castings, Bronze**
*Doehler Die-Casting Co.
*Franklin Die-Casting Corporation
Hoyt Metal Co.
*Light Mfg. & Foundry Co.
Mueller Metals Co.
Scovill Mfg. Co.

Castings, Die**
Doehler Die-Casting Co.
*Franklin Die-Casting Corporation
Hoyt Metal Co.
*Light Mfg. & Foundry Co.
Mueller Metals Co.

Castings, Grey Iron
Link-Belt Co.

Castings, Malleable Iron, D9
*Eberhard Mfg. Co.
*Link-Belt Co.

Castings, Steel, D7
Link-Belt Co.

Chains, Block
Link-Belt Co.
Morse Chain Co.
Whitney Mfg. Co.

Chains, Roller, E3
*Link-Belt Co.
*Whitney Mfg. Co.

Chains, Silent, E2
*Link-Belt Co.
*Morse Chain Co.
Whitney Mfg. Co.

Chains, Tire, Motor-Truck
Arrow Grip Mfg. Co., Inc.

Channels, Window Glass
Dahlstrom Metallic Door Co.

Checks, Door
Carter Co., George R.

Clamps, Hose, C51
Schrader's Son, Inc., A.

Clamps, Machinists'
Eberhard Mfg. Co.
Williams, J. H., & Co.

Cleaners, Windshield
Folberth Auto Specialty Co.

Clips, Spring, H3
Columbus Bolt Works Co.

Clutches, Engine**
*Brown-Lipe Gear Co.

Clutches, Multiple Disc, A1
*Detlaff Co., A. J.

Clutches, Power Transmission
Link-Belt Co.

Coils, Electrical Equipment
Acme Wire Co.
Dayton Engineering Laboratories Co.

Condensation Products
Bakelite Corporation
Condensite Co. of America
General Bakelite Co.
Redmanol Chemical Products Co.

Connecting-Rods
Standard Gauge Steel Co.

Connections, Tire-Pump
Schrader's Son, Inc., A.

Controls**
*Brown-Lipe Gear Co.

Cooling Systems**
*G & O Mfg. Co.
*Long Mfg. Co.
*National Can Co.

Couplings, Flexible
Thermoid Rubber Co.

(Continued on page 102)

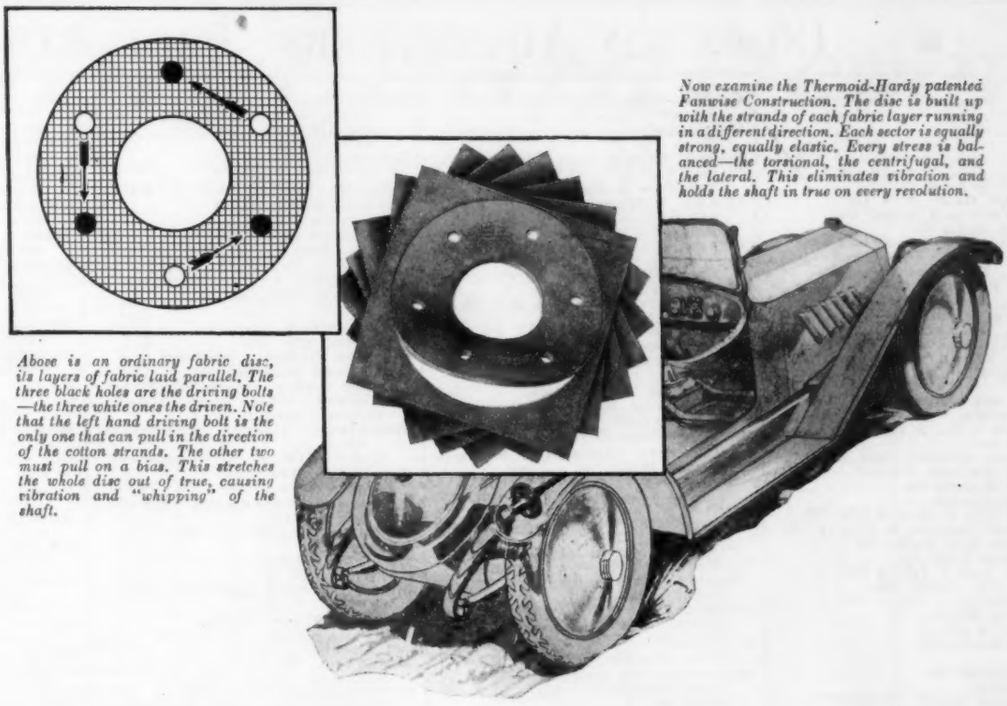
EXPLANATION OF SYMBOLS

Parts and materials followed by key numbers have been standardized by the S. A. E. The numbers refer to S. A. E. HANDBOOK data sheets on which each standard is published.

*Companies whose names are preceded by an asterisk supply the parts or materials under which the company is listed as conforming with the S. A. E. Standard referred to.

**Parts and Materials followed by two asterisks indicate that two or more S. A. E. Standards are applicable. Information as to standards incorporated should be obtained from the manufacturer.

The addresses of companies listed in this index can be obtained from their current advertisements indexed on page 106.



Above is an ordinary fabric disc, its layers of fabric laid parallel. The three black holes are the driving bolts —the three white ones the driven. Note that the left hand driving bolt is the only one that can pull in the direction of the cotton strands. The other two must pull on a bias. This stretches the whole disc out of true, causing vibration and "whipping" of the shaft.

Now examine the Thermoid-Hardy patented Fanwise Construction. The disc is built up with the strands of each fabric layer running in a different direction. Each sector is equally strong, equally elastic. Every stress is balanced—the torsional, the centrifugal, and the lateral. This eliminates vibration and holds the shaft in true on every revolution.

Both fabric discs—*but the resemblance stops there*

Why one universal will stretch while the other holds shaft true on every revolution

When the flexible fabric disc first began to displace the metal universal, it had one big fault—it pulled out of true after a few thousand miles, causing vibration and "whipping" of the entire shaft.

Not until the famous Fanwise Construction of the Thermoid-Hardy disc was worked out did the fabric universal become a practical necessity.

The Thermoid-Hardy Joint was perfected to eliminate backlash and its accompanying troubles. Its flexible fabric discs cushion even the heaviest blows. It transmits a smooth, even flow of power instead of jolts and lost motion.

Examine the Thermoid-Hardy disc, with its patented Fanwise Construction. This disc is built up in layers, but the strands of each layer run in a *different direction*. The result is an even stress at every point—an equal strain between every pair of bolt holes.

Contrast this construction with that of the ordinary disc. Its layers of fabric are laid *parallel*. This means that only the left hand driving bolt can pull in the direction of the strands of cotton. The other two must pull *across*—on a bias. Stretching of the disc soon follows.

Fanwise Construction gives enormous strength

Fanwise Construction has added to elasticity a *rugged strength*. The Thermoid-Hardy universal withstands a torsional strain that twists a two-inch steel shaft—it is good for over 60,000 miles on a heavy truck, over *any* road, and without attention of any sort.

Thermoid-Hardy discs are now packaged for distribution through jobbers and dealers for replacement sales. Full information, prices, and discounts sent on request.

A book you should have

We have prepared a book, "Universal Joints—Their Use and Misuse," that treats the subject from every angle—the mechanical principles, construction, lubrication, manufacture, strength tests, and records of performance. Send for your copy today.

THERMOID RUBBER COMPANY

Sole American Manufacturers

Factory and Main Offices, Trenton, N. J.

New York, Chicago, Los Angeles, Atlanta, Detroit, Seattle, Kansas City, Boston, Cleveland, San Francisco, London, Paris, Turin

LIST OF USERS

Allis Chalmers Mfg. Co.
The Autocar Co.
Available Truck Co
Barley Motor Car Co. (Roamer)
Chandler Motor Car Co.
Crow-Elkhart Motor Corp.
Jas Cunningham Son & Co.
Dart Truck & Tractor Corp
The Dauch Mfg. Co.
Diamond T Motor Car Co.
Doane Motor Truck Co.
Fageol Motors Co.
H. H. Franklin Mfg. Co.
Garford Motor Truck Co.
Gramm-Bernstein Motor Truck Co.
Hawkeye Truck Co.
Hendrickson Motor Truck Co.
Highway Motors Co.
Holt Mfg. Co
Indiana Truck Co.
International Harvester Co., of A., Inc.
International Motor Co.
Jackson Motors Corp.
Kelsey Motor Co.
Kentucky Wagon Mfg. Co., Inc.
King Zeitler Co
Lakewood Eng. Co.
Lexington Motor Co.
Locomobile Co.
Maxwell Motors Corp.
Menominee Motor Truck Co.
Mercer Motors Co.
Moreland Motor Truck Co.

LIST OF USERS

Nelson & LeMoon
E. A. Nelson Automobile Co.
Nelson Motor Truck Co.
D. A. Newcomer Co.
O'Connell Motor Truck Co.
Oliver Tractor Co.
Oneida Motor Truck Co.
Packard Motor Car Co.
Parker Motor Truck Co.
Patriot Motors Co.
Reliance Motor Truck Co.
Reo Motor Car Co.
Reynolds Motor Truck Co.
Root & Van Dervoort Eng. Co.
Sanford Motor Truck Co.
Southwark Fdy. & Mach. Co.
Stoughton Wagon Co.
Studebaker Corp.
Stutes Mar Tractor Co.
Templar Motors Co.
Tioga Steel & Iron Co.
Towmotor Co.
Traffic Motor Truck Co.
Transport Truck Co.
Twin City Four Wheel Drive Co., Inc.
United Motors Co.
Walter Motor Truck Co.
Ward La France Truck Corp., Inc.
Geo. D. Whitcomb Co.
Wichita Motors Co.
H. E. Wilcox Motor Co.
Willys-Overland, Inc.
Zeitler & Lamson Truck & Tractor Co

THERMOID-HARDY
UNIVERSAL JOINT

Makers of "Thermoid Hydraulic Compressed Brake Lining" and "Thermoid Crolide Compound Tires"

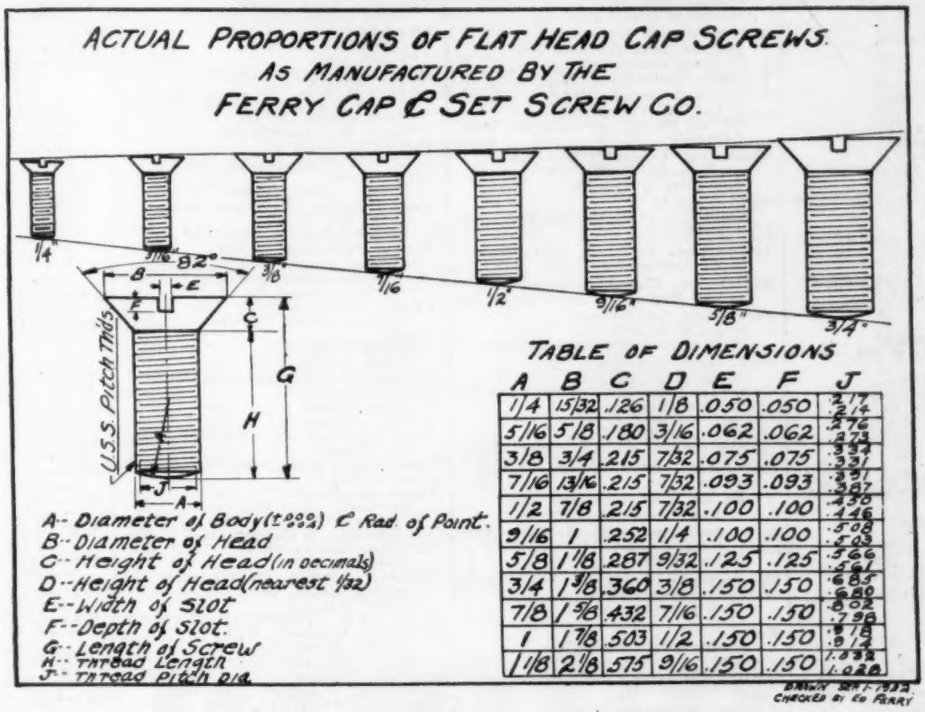
INDEX TO ADVERTISERS' PRODUCTS

Cranes, Portable Electric
Link-Belt Co.
Crankshafts
Canton Drop Forging & Mfg. Co.
Jackson Motor Shaft Co.
Moltrup Steel Products Co.
Park Drop Forge Co.
Standard Gauge Steel Co.
Union Switch & Signal Co.
Wyman-Gordon Co.
Cups, Oil and Grease, C57
*Bowen Products Corporation
Cutouts, Regulator
Briggs & Stratton Co.
Cutouts, Reverse Current
Briggs & Stratton Co.
Cutters, Milling
Haynes Stellite Co.
Cutters, Woodruff
Whitney Mfg. Co.
Dashes
Parish Mfg. Corporation
Dogs, Lathe
Williams & Co., J. H.
Door-Caps
Dahlstrom Metallic Door Co.
Drive, Starting-Motor
Eclipse Machine Co.
Drop-Forgings
Canton Drop Forging & Mfg. Co.
Champion Machine & Forging Co.
Columbus Bolt Works Co.
Park Drop Forge Co.
Sheldon Axle & Spring Co.
Spicer Mfg. Corporation
Union Switch & Signal Co.
Universal Machine Co.
Williams & Co., J. H.
Wyman-Gordon Co.
Dryers
Fuller-Lehigh Co.
Durometers
*Continental Motors Corporation
*Light Mfg. & Foundry Co.
Shore Instrument & Mfg. Co.
*Wankesha Motor Co.
Engines, Motor Truck
*Continental Motors Corporation
*Light Mfg. & Foundry Co.
*Wankesha Motor Co.
Engine Mountings, Fabric
Belflex Corporation
Engines, Passenger Car**
*Continental Motors Corporation
*Light Mfg. & Foundry Co.
Engines, Steam, Automotive
Stumpf Una-Flow Engine Co., Inc.
Engines, Tractor**
*Continental Motors Corporation
*Light Mfg. & Foundry Co.
*Wankesha Motor Co.
Equipment, Pulverized Coal
Fuller-Lehigh Co.
Facings, Clutch, E19
Johns-Manville, Inc.
Thermoid Rubber Co.
Fans
Service Products Corporation
Fans, Radiator, A14a
*Detroit Carrier & Mfg. Co.
Fasteners, Carpet
Carr Fastener Co.
Fasteners, Curtain
Carr Fastener Co.
Fasteners, Hood
Eberhard Mfg. Co.
Feeders
Fuller-Lehigh Co.
Fellos - Bands, Motor - Truck, Pneumatic Tire, G4
*Motor Wheel Corporation
Felt
American Felt Co.
Fenderlights
Stewart-Warner Speedometer Corporation
Fenders
Parish Mfg. Corporation
Fibre, Vulcanized
National Vulcanized Fibre Co.
Flanges, Hub
Crosby Co.
Smith Corporation, A. O.
Floors, Metal
Dahlstrom Metallic Door Co.
Followers, Cam
Wilcox Motor Parts & Mfg. Co.
Forgings, Brass
Mueller Metals Co.
Scovill Mfg. Co.
Forgings, Drop (See Drop-Forgings)
Forgings, Nickel, Silver and Bronze
Mueller Metals Co.
Frames, Rolled Section
Mansfield Steel Corporation
Frames, Pressed Steel
Parish Mfg. Corporation
Smith Corporation, A. O.
Fuses, Electric, B32
*Johns-Manville, Inc.
Gages, Gasoline
Akron-Selle Co.
Nagel Electric Co., W. G.
Winterhoff Gauge Co.
Gages, Oil, B12
Akron-Selle Co.
*Nagel Electric Co., W. G.
Gages, Tire Pressure
Schrader's Son, Inc., A.
Gasoline
Texas Co.
Gears, Bevel
Link-Belt Co.
Van Dorn & Dutton Co.
Gears, Reduction
Van Dorn & Dutton Co.
Waukesha Motor Co.
Gears, Spur
Link-Belt Co.
Van Dorn & Dutton Co.
Gears, Transmission
Canton Drop Forging & Mfg. Co.
Link-Belt Co.
Van Dorn & Dutton Co.
Wyman-Gordon Co.
Gears, Worm
Link-Belt Co.
Van Dorn & Dutton Co.
Generators, Battery Charging (Electric Vehicle)
Westinghouse Electric & Mfg. Co.
Generators (Standard Mountings, B15)
*Atwater Kent Mfg. Co.
*Dayton Engineering Laboratories Co.
*Electric Auto-Lite Co.
*Leece-Neville Co.
*North East Electric Co.
*Owen Dyneto Corporation
Westinghouse Electric & Mfg. Co.
Glasses, Lamp, B6
*Smith Glass Co., L. E.
Governors
Handy Governor Corporation
Graphite
Dixon Crucible Co., Jos.
Greases, Cup and Gear
Dixon Crucible Co., Jos.
Texas Co.
Guards, Radiator
Mansfield Steel Corporation
Handles, Door
Briggs & Stratton Co.
Handles, Machine-Tool
Williams & Co., J. H.
Head-lamps B1
*Corcoran Lamp Co., Thos. J.
Heaters, Passenger-Car Body
Perfection Heater & Mfg. Co.
Hinges, Door
Briggs & Stratton Co.
Eberhard Mfg. Co.
Hinges, Windshield
Eberhard Mfg. Co.
Hitches, Trailer, K42
*Mansfield Steel Corporation
Hoists, Power and Hand
Mansfield Steel Corporation
Holders, Tool
Williams & Co., J. H.
Hood Corners
Carter Co., George R.
Hooks, Towing
Mansfield Steel Corporation
Horns, Hand
Stewart-Warner Speedometer Corporation
Horns, Motor-Driven
Briggs & Stratton Co.
Klaxon Co.
North East Electric Co.
Stewart-Warner Speedometer Corporation
Hose, Gasoline
Thermoid Rubber Co.
Hose, Radiator, C51
*Thermoid Rubber Co.
Housings, Axle
Crosby Co.
Dixon Crucible Co., Jos.
Parish Mfg. Corporation
Smith Corporation, A. O.
Hubs, Wheel
Salisbury Axle Co.
Smith Corporation, A. O.
Ignition-Generators
North East Electric Co.
Instruments, Heat-Indicating
Stewart-Warner Speedometer Corporation
Instruments, Scientific
Shore Instrument & Mfg. Co.
Insulation, Electric
Bakelite Corporation
Condensite Co. of America
General Bakelite Co.
Redmonal Chemical Products Co.
Insulation, Molded
Bakelite Corporation
Condensite Co. of America
General Bakelite Co.
Redmanol Chemical Products Co.
Irons, Body
Columbus Bolt Works Co.
Jacks, Wheel
Arrow Grip Mfg. Co., Inc.
Jars, Storage Battery, B39
*Marko Storage Battery Co.
Keys, Machine
Moltrup Steel Products Co.
Keys, Spring
Williams & Co., J. H.
Keys, Woodruff
Moltrup Steel Products Co.
Standard Gauge Steel Co.
Whitney Mfg. Co.
Leather
Carter Co., George R.
Lenses (See Glasses, Lamp)
Lining, Brake, C55
*Johns-Manville, Inc.
*Thermoid Rubber Co.
Locks, Door
Briggs & Stratton Co.
Lubricants
Dixon Crucible Co., Jos.
Texas Co.
Lubricating Systems
Bassick Mfg. Co.
Bowen Products Corporation
Machines, Balancing
Olsen Testing Machine Co., Tinius
Machines, Bolt Threading
Universal Machine Co.
Machines, Power Transmission
Link-Belt Co.
Machines, Testing
Olsen Testing Machine Co., Tinius
Magnetos (Standard Mountings, B14)
*Scintilla Magneto Co., Inc.
*Teagle Co.
Material, Seat
Carr Co., F. S.
Material, Top and Curtain
Carr Co., F. S.
Mirrors, Rear Vision
Stewart-Warner Speedometer Corporation
Moldings, Cold-Drawn Steel
Dahlstrom Metallic Door Co.
Molybdenum, Metallic
Vanadium Corporation of America
Motors, Electric Vehicle
Westinghouse Electric & Mfg. Co.
Motors (See Engines)
Motors, Starting (See Starting Motors)
Mountings, Torque-Arms, Fabric
Belflex Corporation
Nails
Interstate Iron & Steel Co.
Nuts
Columbus Bolt Works Co.
Nuts, Castle, C2
*Ferry Cap & Set Screw Co.
Nuts, Hexagon, C2
*Ferry Cap & Set Screw Co.
Nuts, Slotted, C12 and C14
*Ferry Cap & Set Screw Co.
Nuts, Thumb
Williams & Co., J. H.
Odometers, Hub, F2
*Johns-Manville, Inc.
Stewart-Warner Speedometer Corporation
Oils (See Lubricants)
Packing, Asbestos and Fibrous
Johns-Manville, Inc.
Paints
Dixon Crucible Co., Jos.
Panels, Instrument
Dahlstrom Metallic Door Co.
Parts, Pressed Steel (See Stampings)
Pencils, Drawing
American Lead Pencil Co.
Dixon Crucible Co., Jos.
Pinions, Starting Motor, H18
*Electric Auto-Lite Co.
Pins, Cotter, C7
*Williams & Co., J. H.
Pins, Piston
Universal Machine Co.
Wilcox Motor Parts & Mfg. Co.
Pins, Rod-End, C10
*Columbus Bolt Works Co.
Pipe Fittings, Compression Type
Mueller Metals Co.
Ohio Metal Products Co.
Pipe Fittings, Flared-Tube Type, C46
Mueller Metals Co.
Piston-Rings, A6
*General Piston Ring Co.
Piston Ring Co.
Reus Mfg. Co.
Wilcox Motor Parts & Mfg. Co.
Plates, Flattened, Ground and Polished
Moltrup Steel Products Co.
Powerplants, Industrial
Waukesha Motor Co.
Power Take-Offs, E1
Brown-Lipe Gear Co.
Products, Screw-Machine
Link-Belt Co.
Mueller Metals Co.
Ohio Metal Products Co.
Rich Tool Co.
Scovill Mfg. Co.
Spicer Mfg. Corporation
Standard Gauge Steel Co.
Propeller-Shafts
Salisbury Axle Co.
Spicer Mfg. Corporation
Pulverizers, Coal
Fuller-Lehigh Co.
Push-Rods
Wilcox Motor Parts & Mfg. Co.
Pyroscopes
Shore Instrument & Mfg. Co.
Racks, Machine
Moltrup Steel Products Co.
Radiators**
*G & O Mfg. Co.
*Long Mfg. Co.
*National Can Co.
Rails, Robe
Carter Co., George R.
Rectifiers, Battery Charging
Westinghouse Electric & Mfg. Co.
Reel
Stewart-Warner Speedometer Corporation
Regulators, Temperature
Fulton Co.
Regulators, Window
Dura Co.
Relays, Cut-Out
North East Electric Co.
Retainers, Ball
Bearings Co. of America
Ribbons, Fender
Dahlstrom Metallic Door Co.
Rims, Pneumatic Tire, G1 and G2
*Motor Wheel Corporation
Rivets, Brass and Copper
Scovill Mfg. Co.
Rivets, Steel
Columbus Bolt Works Co.
Interstate Iron & Steel Co.
Rod-Ends, C8
*Columbus Bolt Works Co.
*Eberhard Mfg. Co.
Rods, Brass, D114, D115 and D124
*Columbus Bolt Works Co.
*Mueller Metals Co.
*Scovill Mfg. Co.
Rods, Bronze and Copper
Mueller Metals Co.
Rods, Fibre
National Vulcanized Fibre Co.
Roller Bearings (See Bearings, Roller)
Running-Boards
Parish Mfg. Corporation
Smith Corporation, A. O.
Scleroscopes
Shore Instrument & Mfg. Co.
Screws, Cap, C1
*Ferry Cap & Set Screw Co.
*Scovill Mfg. Co.
Screws, Thumb
Williams & Co., J. H.
Searchlights
Stewart-Warner Speedometer Corporation
Shaft-Ends, C14
*Brown-Lipe Gear Co.
Shafting
Moltrup Steel Products Co.
Shafts, Rear Axle
Salisbury Axle Co.
Shapes (Extruded) Brass, Bronze and Copper
Mueller Metals Co.
Sheets, Brass, D111
*Scovill Mfg. Co.
Sheets, Fibre
National Vulcanized Fibre Co.
Shims, Laminated
Laminated Shim Co., Inc.
Sills, Body
Smith Corporation, A. O.
Solder, D101
Hoyt Metal Co.
Speedometers
Stewart-Warner Speedometer Corporation
Spokes, Wood, Motor Truck, F1
*Motor Wheel Corporation
Spokes, Wood, Passenger Car, F1a
*Motor Wheel Corporation
Spring-Shackles, Fabric
Belflex Corporation
Springs, Coiled
Gibson Co., Wm. D.
Springs, Flat
Gibson Co., Wm. D.
Springs, Motor Truck, H9
*Perfection Spring Co.
Sheldon Axle & Spring Co.
*Standard Steel Spring Co.
Springs, Passenger-Car, H8
*Perfection Spring Co.
Sheldon Axle & Spring Co.
*Standard Steel Spring Co.
Springs, Tractor
Standard Steel Spring Co.
Sprockets, Roller-Chain, E4
*Link-Belt Co.
*Whitney Mfg. Co.

(Continued on page 104)

The Index to Advertisers is given on page 106

The Standard Screw


ACTUAL PROPORTIONS OF FLAT HEAD CAP SCREWS
AS MANUFACTURED BY THE
FERRY CAP & SET SCREW CO.
82°
U.S.S. Pitch Thds.
A-- Diameter of Body (to 2nd) & Rad. of Point.
B-- Diameter of Head
C-- Height of Head (in decimals)
D-- Height of Head (nearest 1/32)
E-- Width of Slot
F-- Depth of Slot.
G-- Length of Screw
H-- Thread Length
J-- Thread Pitch dia.
TABLE OF DIMENSIONS
A B C D E F J
1/4 15/32 .126 1/8 .050 .050 .217 .214
5/16 5/8 .180 3/16 .062 .062 .276 .273
3/8 3/4 .215 7/32 .075 .075 .337 .331
7/16 13/16 .215 7/32 .093 .093 .337 .331 .307
1/2 7/8 .215 7/32 .100 .100 .450 .446
9/16 1 .252 1/4 .100 .100 .508 .503
5/8 1 1/8 .287 9/32 .125 .125 .566 .561
3/4 1 3/8 .360 3/8 .150 .150 .685 .680
7/8 1 5/8 .432 7/16 .150 .150 .802 .796
1 1 7/8 .503 1/2 .150 .150 .918 .912
1 1/8 2 1/8 .575 9/16 .150 .150 1.032 1.020

Ferry Flat Head Steel Cap Screws

The same exacting care is used in the making of Ferry Flat Head Steel Cap Screws that is taken in the manufacture of all Ferry Process Screws.

Their uniform performance both in rugged strength and precision accuracy has been another great factor in building the reputation they now enjoy among careful buyers.

They are perfectly machined from top to bottom and accurately slotted so a screw driver will "stay put" no matter how great the pressure.

Reprints of this series of advertisements on Ferry Standard Screws will be sent upon request. Your Engineering, Drafting and Purchasing Departments should have them. Write today—

"If it's upset—it must be heat-treated."

THE FERRY CAP AND SET SCREW CO., Cleveland, Ohio

FERRY

PROCESS SCREWS

INDEX TO ADVERTISERS' PRODUCTS

Sprockets, Silent-Chain
Link-Belt Co.
Whitney Mfg. Co.

Stabilators
Watson Co., John Warren

Stampings
Crosby Co.
Motor Wheel Corporation
Parish Mfg. Corporation
Scovill Mfg. Co.,
Smith Corporation, A. O.
Spicer Mfg. Corporation

Starter-Generators
Dayton Engineering Laboratories Co.
North East Electric Co.

Starting, Automatic Meshing Drive for
Eclipse Machine Co.

Starting-Motors (Standard Mountings, B16)
*Atwater Kent Mfg. Co.
*Dayton Engineering Laboratories Co.
*Electric Auto-Lite Co.
*Leece-Neville Co.
*North East Electric Co.
*Owen Dyneto Corporation
Westinghouse Electric & Mfg. Co.

Steel, Carbon, D4
*Atlas Steel Corporation
*Interstate Iron & Steel Co.
Standard Gauge Steel Co.
*Union Drawn Steel Co.

Steel, Chromium, D6
*Atlas Steel Corporation
*Central Steel Co.
*Interstate Iron & Steel Co.

Steel, Chromium-Vanadium, D6
*Atlas Steel Corporation
*Central Steel Co.
*Interstate Iron & Steel Co.

Steel, Leaf-Spring, D77
Interstate Iron & Steel Co.

Steel, High-Chromium
Atlas Steel Corporation

Steel, Molybdenum
Interstate Iron & Steel Co.

Steel, Nickel, D5
*Atlas Steel Corporation
*Central Steel Co.
*Interstate Iron & Steel Co.
*Union Drawn Steel Co.

Steel, Nickel-Chromium, D5
*Atlas Steel Corporation
*Central Steel Co.
*Interstate Iron & Steel Co.
*Union Drawn Steel Co.

Steel, Silico-Manganese, D6
*Atlas Steel Corporation
*Central Steel Co.
*Interstate Iron & Steel Co.

Steel, Screw Stock, D4
Moltrup Steel Products Co.
Standard Gauge Steel Co.
Union Drawn Steel Co.

Steel, Tungsten, D6
*Atlas Steel Corporation
Stewart-Warner Speedometer Corporation

Steering Gears (Standard Wheel Hub), J4
*Ross Gear & Tool Co.

Stop Lights
Stewart-Warner Speedometer Corporation

Superheat System, Gasoline
Deppé Motors Corporation

Switches, Combination
Dayton Engineering Laboratories Co.

Switches, Lighting
Briggs & Stratton Co.
Westinghouse Electric & Mfg. Co.

Switches, Starting
Briggs & Stratton Co.
Dayton Engineering Laboratories Co.
Electric Auto-Lite Co.
Leece-Neville Co.
North East Electric Co.
Westinghouse Electric & Mfg. Co.

Sylphon, Automobile, A13
Fulton Co.

Systems, Lubrication (See Lubricating Systems)

Systems, Pulverized-Material Conveying
Fuller-Lehigh Co.

Tachometers (with Standard Drive), C75
*Johns-Manville, Inc.

Tacks
Interstate Iron & Steel Co.

Tank Caps and Flanges
Akron-Selle Co.

Tanks, Vacuum, C45
*Stewart-Warner Speedometer Corporation

Tape, Insulated
Johns-Manville, Inc.

Tappets
Wilcox Motor Parts & Mfg. Co.

Testers, Hardness
Shore Instrument & Mfg. Co.

Thermostats, A14
Bishop & Babcock Co.
*Fulton Co.

Timer-Distributors, B13
*Atwater Mfg. Co.
*Dayton Engineering Laboratories Co.
*Electric Auto-Lite Co.
*North East Electric Co.

Tire Carriers
Detroit Carrier & Mfg. Co.

Tire Locks
Detroit Carrier & Mfg. Co.

Tire-Pumps, Transmission Type, E1
Detroit Carrier & Mfg. Co.

Tires, Pneumatic, G1
Goodrich Rubber Co., B. F.
Kelly-Springfield Tire Co.
*Thermoid Rubber Co.

Tires, Solid, G10
Kelly-Springfield Tire Co.

Tools
Haynes Stellite Co.
Williams & Co., J. H.

Tools, Piston Regrooving
*Reus Mfg. Co.

Torque-Arms
Smith Corporation, A. O.

Torsion-Rod Assemblies
Steel Products Co.

Tractors, Industrial
Baker R & L Co.

Transmissions**
*Brown-Lipe Gear Co.
*Durston Gear Corporation
*Light Mfg. & Foundry Co.

Trucks, Industrial
Baker R & L Co.

Tubing, Brass, D116
*Mueller Metals Co.
*Scovill Mfg. Co.

Tubing (Tapered), Brass

Tubing, Copper, D117
*Mueller Metals Co.
*Scovill Mfg. Co.

Tubing, Fibre
National Vulcanized Fibre Co.

Tubing, Flexible, C52
*Titeflex Metal Hose Corporation

Tubing, Flexible Metal, C52
Titeflex Metal Hose Corporation

Tubing, Rubber
Thermoid Rubber Co.

Tubing, Steel, D75
*Smith Corporation, A. O.

Tubing, Windshield
Dahlstrom Metallic Door Co.

Tungsten, Metallic
Vanadium Corporation of America

Universal-Joints, E6
*Spicer Mfg. Corporation
*Thermoid Rubber Co.
Universal Machine Co.

Valve-Lifters
Rich Tool Co.

Valves, Fuel Reserve
Service Products Corporation

Valves, Poppet, A4
*Bunting Brass & Bronze Co.
*Rich Tool Co.
Steel Products Co.
*Toledo Steel Products Co.
Wilcox Motor Parts & Mfg. Co.

Valves, Tire
Schrader's Son, Inc., A.

Ventilators, Cowl
Service Products Corporation

Voltmeters, B12
*Sterling Mfg. Co.
Westinghouse Electric & Mfg. Co.

Washers, Air
Stewart-Warner Speedometer Corporation

Washers, Fibre
National Vulcanized Fibre Co.

Washers, Lock, C5
Shakeproof Screw & Nut Lock Co.

Washers, Plain, C5c
Interstate Iron & Steel Co.

Washers
Columbus Bolt Works Co.

Welding, Electric
Steel Products Co.

Welding Rod, Bronze
Mueller Metals Co.

Wheels, Pressed Steel Disc
Motor Wheel Corporation

Wheels, Wood
Motor Wheel Corporation

Wicks, Felt
American Felt Co.

Wire (See Cable, Insulated)

Wire, Magnet
Acme Wire Co.

Wire Products
Interstate Iron & Steel Co.

Wrenches
Williams & Co., J. H.

The Index to Advertisers is given on page 106

How Do You Correct Your Connecting Rods?

Plate No. 2039
Pat. Applied for

The Standard for Quality the World Over

All connecting rods should be corrected with reference to their total weight and location of center of gravity, i. e., each end must weigh the same and the sum total of the two ends the same.

The Olsen-Lundgren Automatic Weighing Connecting Rod Scale will at a glance and in a single operation, weigh such parts accurately and so that each and every connecting rod will weigh the same.

Standardize your connecting rods and reduce your costs by the Olsen-Lundgren method

OLSEN-CARWEN STATIC-DYNAMIC BALANCING MACHINES

Eliminate Vibration—Secure Perfect Balance with Speed and Economy

The Olsen-Carwen Machine is made in many sizes and types to balance any rotating parts from the smallest to the largest rotor made. Now used by all the leading up-to-date automobile and motor manufacturers throughout the country.

SOLE MANUFACTURERS

TINIUS OLSEN TESTING MACHINE COMPANY

500 North Twelfth Street
Philadelphia, Pa., U. S. A.

FOREIGN REPRESENTATIVES—*Messrs. R. S. Stokvis & Fils, Paris, France; Brussels, Belgium; Rotterdam and Amsterdam, Holland. Edw. G. Herbert, Ltd., Manchester, Eng. Andrews & George Company, Tokyo, Japan.*

There is only one best in every field

— and the *best* always gives better service — better satisfaction.

MUELLER Brass and Copper Tubing

is the *one best* product for those who use Brass or Copper Tubing — *best by test.*

The reasons for Mueller leadership

Accurate laboratory control of every heat — plus three generations of uninterrupted experience — and the firm determination to excel — these are the prime factors in MUELLER supremacy.

You can quickly prove the exceptional merits of MUELLER Brass Tubing and MUELLER Copper Tubing by actual test in your own factory.

We will gladly quote prices and deliveries on request.

MUELLER METALS CO., PORT HURON, MICH.

Sales Offices: New York, Philadelphia, Buffalo, Pittsburgh, Cleveland, Dayton, Detroit, Indianapolis, Chicago, Minneapolis, New Orleans, San Francisco.

Makers of "Red Tip" Brass Rod; Welding Rod; Brass and Copper Tubing; Forgings and Castings in Brass and Bronze; also Brass Screw Machined Products.

Associated with H. Mueller Manufacturing Co., Decatur, Ill., and H. Mueller Mfg. Co., Ltd., Sarnia, Ont. Makers of Water, Plumbing and Gas Brass Goods and Tools.

INDEX TO ADVERTISERS

A

Acme Wire Co..... 32
Akron-Selle Co. 95
American Felt Co..... 2
American Flatlite Co..... 88
American Lead Pencil Co..... 90
Arrow Grip Mfg. Co., Inc..... 94
Atlas Ball Co..... 8
Atlas Steel Corporation..... 39
Atwater Kent Mfg. Co..... 28

B

Bakelite Corporation 29
Baker R & L Co..... 37
Bantam Ball Bearing Co..... 6
Bassick Mfg. Co..... 36
Bearings Co. of America..... 96
Belflex Corporation 41
Biflex Products Co..... 98
Bishop & Babcock Co..... 40
Bowen Products Corporation..... 20
Bower Roller Bearing Co..... 38
Briggs & Stratton Co..... 25
Brown-Lipe-Chapin Co. 47
Brown-Lipe Gear Co..... 79
Brown Mfg. Co., Jno. W..... 98
Bunting Brass & Bronze Co.... 52
Byrne, Kingston & Co..... 54

C

Canton Drop Forging & Mfg. Co. 95
Cardboard Cutting & Supply Co.. 98
Carr Co., F. S..... 26
Carr Fastener Co. 50
Carter Co., George R..... 85
Central Steel Co..... 66
Champion Machine & Forging Co. 42
Cleveland and Buffalo Transit Co. 81
Columbus Bolt Works Co..... 98
Condensite Co. of America..... 29
Consulting Engineers 90
Continental Motors Corporation. 15
Corcoran Lamp Works Co., Thomas J..... 88
Crosby Co. 98

D

Dahlstrom Metallic Door Co.... 81
Dayton Engineering Laboratories Co. 67
Dayton Steel Foundry Co..... 48
Deppé Motors Corporation..... 72
Detlaff Co., A. J..... 68
Detroit Carrier & Mfg. Co..... 94
Dixon Crucible Co., Joseph..... 3
Doehler Die-Casting Co..... 16
Dura Co. 18, 19
Durston Gear Corporation..... 98

E

Eberhard Mfg. Co..... 88
Eclipse Machine Co..... 98
Electric Auto-Lite Co..... 59

F

Fafnir Bearing Co..... 87
Federal Bearings Co., Inc..... 22
Ferry Cap & Set Screw Co.....103
Firestone Tire & Rubber Co.... 24
Folberth Auto Specialty Co.... 98
Franklin Die-Casting Corporation 85
Fuller-Lehigh Co. 97
Fulton Co. 12

G

G & O Mfg. Co..... 97
General Bakelite Co..... 29
General Phonograph Mfg. Co... 93
Gibson Co., Wm. D..... 94
Gilliam Mfg. Co..... 58
Gurney Ball Bearing Co..... 83

H

Handy Governor Corporation.... 97
Hayes Mfg. Co..... 23
Haynes Stellite Co..... 60
Highland Body Mfg. Co..... 70
Hoover Steel Ball Co..... 83
Houdaille Co. 63
Hoyt Metal Co..... 78
Hyatt Roller Bearing Co..... 65
Hydraulic Brake Co..... 13

I

International Insulating Corporation 79
Interstate Iron & Steel Co..... 43

J

Jackson Motor Shaft Co..... 83
Johns-Manville, Inc..... 97

K

Kelly-Springfield Tire Co..... 10
Kerite Insulated Wire & Cable Co. 1
Klaxon Co. 33

L

Laminated Shim Co., Inc..... 99
Leece-Neville Co..... 92
Lees Bradner Co..... 21
Light Mfg. & Foundry Co..... 96
Link-Belt Co. 108
Long Mfg. Co..... 69

M

Madison-Kipp Corporation..... 92
Mansfield Steel Corporation..... 97
Marko Storage Battery Co..... 99
Mather Spring Co..... 76
Members' Professional Cards... 90
Men Available..... 68
Miller & Hurst Corporation, Jas. F. 6
Moltrup Steel Products Co..... 99
Morse Chain Co..... 61
Motor Wheel Corporation..... 62
Mueller Metals Co..... 105
Muzzy-Lyon Co. 45

N

Nagel Electric Co., W. G..... 90
National Can Corporation..... 91
National Vulcanized Fibre Co... 82
New Departure Mfg. Co..... 77
Norma Co. of America..... 84
North East Electric Co..... 96
Notes and Reviews..... 10

O

Ohio Metal Products Co..... 93
Olsen Testing Mach. Co., Tinius. 104
Owen-Dyneto Corporation..... 86

P

Packard Electric Co..... 44
Parish Mfg. Corporation..... 31
Park Drop Forge Co..... 99
Perfection Heater & Mfg. Co..... 99
Piston Ring Co..... 64
Positions Available..... 80
Prest-O-Lite Co., Inc.....34, 35

R

Redmanol Chemical Products Co. 29
Reus Mfg. Co..... 27
Ross Gear & Tool Co..... 71

S

S K F Industries, Inc..... 9
Scintilla Magneto Co., Inc..... 87
Scovill Mfg. Co. 92
Service Products Corporation... 80
Shafer Bearing Corporation 79
Shakeproof Screw & Nut Lock Co. 14
Shore Instrument & Mfg. Co..... 99
Shuler Axle Co., Inc..... 97
Smith Corporation, A. O..... 91
Standard Steel & Bearings, Inc. 5
Standard Steel Spring Co..... 95
Steel Products Co..... 7
Sterling Mfg. Co..... 92
Stewart-Warner Speedometer Corporation 46
Stumpf-Una-Flow Engine Co., Inc. 99
Sun Oil Co..... 107

T

Teagle Co. 93
Ternstedt Mfg. Co. Inside Back Cover
Texas Co. 93
Thermoid Rubber Co.....11, 101
Timken-Detroit Axle Co..... 57
Timken Roller Bearing Co..... 49
Titeflex Metal Hose Corporation. 96

U

U. S. Ball Bearing Mfg. Co..... 53
Union Drawn Steel Co..... 95
Union Switch & Signal Co..... 89

V

Valentine & Co..... 99
Van Dorn & Dutton Co..... 94
Vanadium Corporation of America 73

W

Watson Co., John Warren, Inside Front Cover
Waukesha Motor Co..... 56
Westinghouse Electric & Mfg. Co.. 17
Westinghouse Union Battery Co. 55
Whitney Mfg. Co..... 51
Willard Storage Battery Co.... 75
Williams & Co., J. H..... 90
Wood Hydraulic Hoist & Body Co. 4
Wyman-Gordon Co., Opposite first reading page

Z

Zenith-Detroit Corporation..... 74

An index to advertisers' products is given on pages 100, 102 and 104

SUN OILS

Design your lubrication

When you design an engine, you design each part to do efficiently the job assigned to it; the same with any other element of car construction.

It's the same, too, with lubrication. Engineers agree as to the importance of lubrication; the most vital single factor in cost of maintaining and operating a car. And proper lubrication is largely a problem of design.

Proper lubrication means more than just oil film protection for working surfaces. It includes effective cooling; the cushioning and quieting ability of a lubricant; and most important, the function of effective piston lubrication with minimum carbonization.

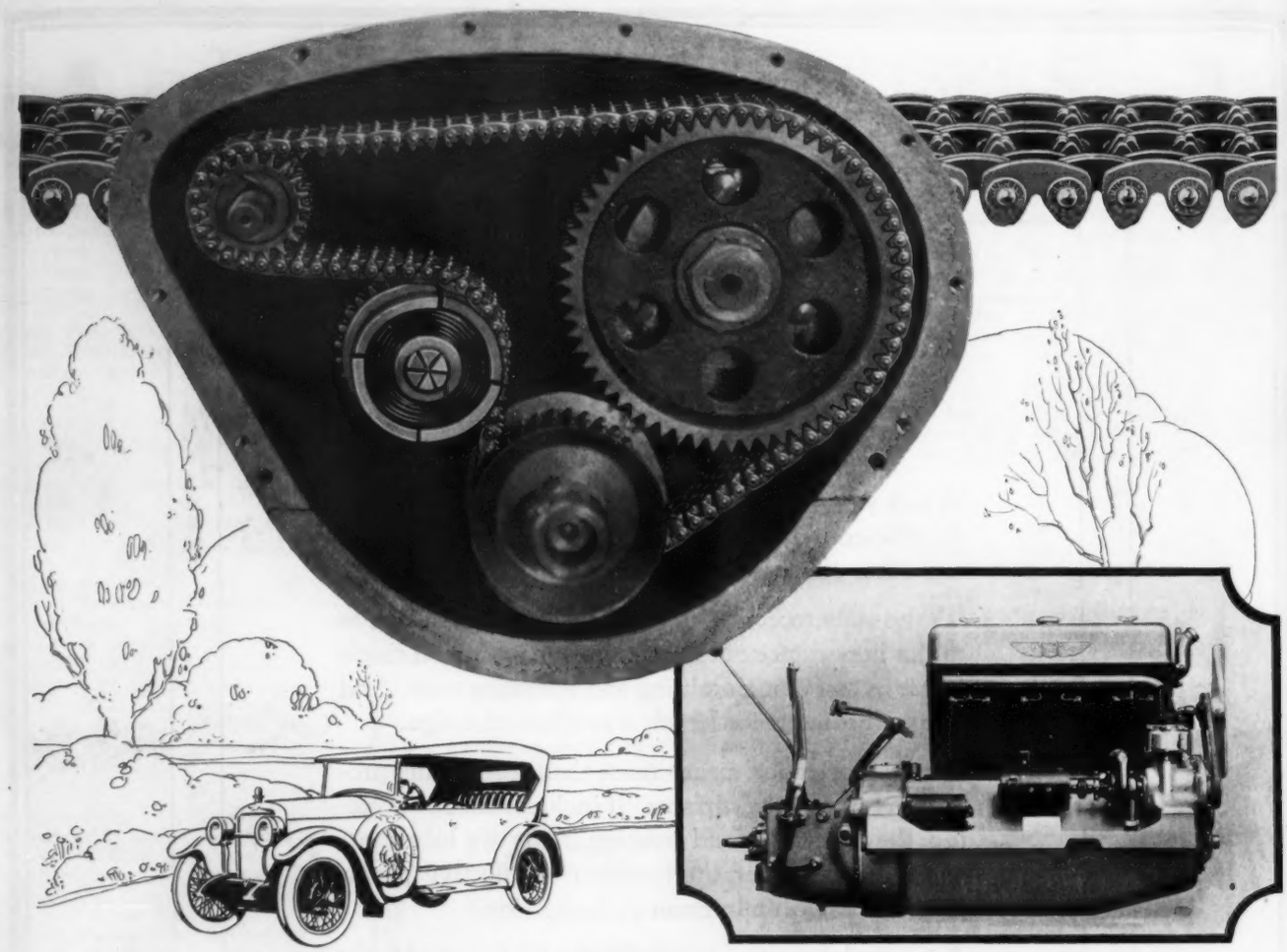
Accurate lubrication is simplified with Sunoco Motor Oils; through a choice of a number of types; each type a pure, straight-run, wholly distilled lubricant. Sunoco is good oil to recommend.

Proper lubrication — its correct design, and application — has been the business of this company for more than twenty years.

SUN OIL COMPANY, Philadelphia

Branches and Agents in Principal Cities

SUNOCO
THE DISTILLED OIL



The H. C. S. "Front-End" is Quiet

USED ON THE FOLLOWING:

CARS

Haynes
Paige 6-70
Stutz Six
Auburn Six-Supreme
H. C. S. Series IV, Model 6
Willys-Knight
King 8
Roamer
Mercer 4
Brewster-Knight
Crane-Simplex
Revere
Meteor 4
Richelieu
Frontenac
Helmes

MOTORS

Weidely
Ansted
Beaver
Rochester-Duesenberg
Wisconsin, Type Y
Kermath Marine Engine
Midwest

Quiet "front-end" drives! That's the requirement demanded by car buyers today.

H. C. S. secured a quiet "front-end" drive when they adopted Link-Belt Silent Chain—and they got more than quiet running!

Automatic, Reliable Chain Adjustment!

The famous Link-Belt Automatic Chain Tightener (and Vibration Dampener) keeps just the right operating tension on the chain at all times—hand takeup is not needed.

The Automatic Chain Takeup and the Link-Belt Silent Chain Drive is the winning combination. Learn more about it.

LINK-BELT COMPANY, INDIANAPOLIS

1224

LINK-BELT

SILENT CHAIN FRONT END DRIVES

New!

and

Lower Priced

Here are three *new* Ternstedt products that provide a splendid opportunity for builders of automobile bodies to clip production costs and still maintain high quality.

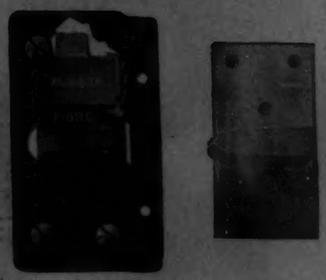
Simplified design, less costly methods of manufacture and immense volume production make it possible to offer these body-building essentials at a substantially lower figure than has ever before been quoted.

Samples of all three are now ready for distribution. Send for them. Note their *practical* and *durable* construction. You'll readily agree they are worthy of installation in *any* motor car body and—

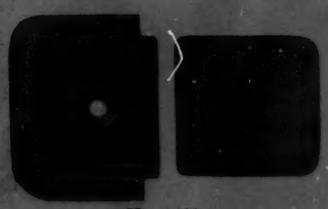
You'll get a new idea of value when you learn how little they cost.

TERNSTEDT MANUFACTURING COMPANY . . . . DETROIT

Division of Fisher Body Corporation



No. 1210
Ideal *Special*
Dovetail Door Bumper



No. 1409
Eclipse
Rubber Door Bumper

No. 1336
Curtain Roller
End Post

FOREIGN REPRESENTATIVES:

FOREIGN TRADERS COMPANY, Inc.
114 Nassau Street, New York City

JACKSON-BALANCES, Limited
No. 1 Charles Place, Drummond St., Euston, N. W. 1, London, Eng.

TOM WILLIAMS, Esq.
Moreno 631, Buenos Aires, Argentine Republic, S. A.

TERNSTEDT

Largest Manufacturers of

AUTOMOBILE BODY HARDWARE

in the World

The SUMMER MEETING

Spring Lake, N. J., June 19-23

THE Summer Meeting will feature the subjects of four-wheel brakes, large section air-cushion tires, headlamp illumination and glare, fuel economy and crankcase oil dilution. Instructive demonstrations will be a part of all sessions. The social and recreational program guarantees many pleasant hours among one's friends. Railroad fares are reduced and special train accommodations provided. Reservations are being received in large numbers, and all members are urged to forward their blanks without delay.

JUNE, 1923